

General Reggoli.

*Compendium of the Cortell
see pp 3-6*

A Recent Trip to Italy, Egypt, Southern France and Spain.

INTERESTING FACTS AND PERSONAL EXPERIENCES.

BY

Dr. ELMER L. CORTHELL,
Civil and Consulting Engineer.



Reprinted from PROFESSIONAL MEMOIRS, Corps of Engineers, United States Army, and Engineer Department At Large [May-June, 1915].



PROVINCIA DI TORINO
BIBLIOTECA

Legato Anselmi

OA. - b -

1.213



A Recent Trip to Italy, Egypt, Southern France and Spain.

*INTERESTING FACTS AND PERSONAL EXPERIENCES.**

BY

Dr. ELMER L. CORTHELL,
Civil and Consulting Engineer.

I will undertake to give you an outline and the principal features of a most interesting and instructive excursion from Bern to Bern, occupying three months of the winter of 1912-1913 and traversing Italy, Egypt, the Nile up to Assuan, the Mediterranean via Marseilles to Gibraltar, Southern Spain to Madrid, and thence to Bern via Paris.

As the visit contemplated not only historical scenes in Egypt and Spain, but also meeting engineering acquaintances and an examination of their important works, I may be excused for not going into detail upon the subjects treated in the guide books and which all tourists can see for themselves under competent guides, as I wish to draw attention to the engineering works of ancient and modern times and those now under construction.

At the International Congress of Navigation held at Philadelphia last summer, it was our duty and pleasure to receive and welcome the delegates and members from many countries on the docks, on their arrival at New York and Hoboken, on sixteen different steamships—about 250 delegates—arranging for their baggage and tickets for Philadelphia, or taking them to their hotels, and passing their baggage free without examination. This continued for ten or twelve days.

Then, after the Congress, were the extended excursions in the United States and Canada, where we did what we could to assist the delegates. And now you ask, "Why inflict us with these

*Contributed by Dr. Elmer L. CortHELL, Civil and Consulting Engineer, 149 Broadway, New York, N. Y.

Congress matters?" Because it was the intimate acquaintance, friendship and appreciation of these delegates that made our trip to Italy, Egypt, Spain and France much more interesting, instructive and enjoyable than it would otherwise have been, and furnished an "open sesame" to the very things we wished to see in all these countries.

In preparation for this voyage of three months, various books on the countries or parts of countries to be visited were sent for to Edward Stanford, London, and studied. Since our youth, Washington Irving's "Tales of the Alhambra" and J. S. C. Abbott's histories had never been forgotten; also the hotel list was carefully examined, and from the data obtained the points to be visited, and the time required at each, was decided upon. The best books were found to be Murray's "Rome and Campaigna," Murray's "Egypt and the Sudan," Percy Wither's "Egypt of Yesterday and To-Day," published by Grant Richards, London, 1909, and "The Nile," by E. A. Wallis Budge, published by Thomas Cook & Son, and last, but not least, a small book, "Egypt and the Nile," by Cook, which is absolutely necessary if the Nile voyage be made in a Cook's tourist steamer, and in Spain, Baedeker, and that lovely little "Castilian Days," by the lamented John Hay. As Monsieur Voisin Bey, the aged (94 years old) constructor of the Suez Canal, had presented me two years before with his monumental work on the Suez Canal—seven volumes and a book of plates—which I had read carefully, this with a long-time knowledge of this great work, which till now I had never seen—all prepared us intelligently for the trip.

The question then arose as to the method of travel, and we decided to try the "Inclusive Independent Travel" system of Thomas Cook & Son of London, which, after our experience, we can heartily recommend; but let it be understood we hold no brief for this company nor for any of the hotels patronized. The latter were generally good, whether selected by us or by Cook. I wrote to the chief office at London, stating quite in detail what we wished to do and asked for an itinerary and estimate. For your information it should be stated that the system of "Inclusive Independent Travel" is a lump sum contract (a forfeit) by which by the payment in advance of the amount of the estimate Thos. Cook & Son undertake to take you through

and pay all expenses, including railroad and steamship and steamboat fares, hotels, conveyance to and from them, meals on trains, private guide and carriages for sightseeing, donkeys on the Nile voyage, gratuities to drivers and entrance fees to places of interest.

The detailed itinerary gives all information required, times of departure and arrival of trains; rooms are secured in advance by the London office; agencies in all the cities, or if no agencies exist, the hotels are notified to have a good guide and carriage at the hotel on a certain day and hour as given in the itinerary. On arrival at a station Cook's agent, or the hotel agent, is looking out for you. In fact, all expenses are included, and hotel, guide and meals in the train restaurants are paid by coupons bound in a small book, to be torn out in the order required. Expenses that are not included are excess baggage, station porters, hotel tips, laundry, etc., and you must not assume that these, and many others, are trifles.

The London office furnishes a conveniently bound pocket itinerary, about 6 by 4 inches (15 cm. by 10 cm.), which gives all details for each place on each page. The whole trip with stops took in the following places: Milan, Florence, Rome, Naples, Pompeii, Cava, Amalfi, Sorrento, Capri, Cairo, Ismailia, Nile voyage to Assuan, and return to Luxor and train to Cairo, Port Said, P. & O. steamer to Marseilles to Gibraltar, Algeciras, Granada, Seville, Cordova, Madrid, Toledo, Escorial, Paris.

I need not tell you that between Bern and Milan there is much to see of engineering interest and our personal acquaintance with Italian engineers has at various times helped much in examination of works; and let me say here that an acquaintance of many years with them and a study of their educational methods, ending with an examination of the Royal Technical School at Rome, close against that wonderful statue of Moses, of heroic size, led me to say in my report in 1898 on engineering education for the University of Chicago, that the thorough practical education of the Italian engineer fits him for his splendid constructions of the last six centuries, which we find all the way from the Italian lakes to Sicily, and gives the Italian that practical engineering sense that makes him a composite engineer, combining the technique of the Frenchman and the practical qualities of the Englishman.

A paper of great interest could be written on his irrigation and navigation works in the north of Italy—Lombardy and Piedmont—Milan and Turin. These works, some of them, at their initiation go back to the Thirteenth Century—650 years; and is it any wonder that with this long period and with extensive plains and with an innate genius for such work, we find all about us on the ride from the Alps to Milan and Turin perhaps the finest irrigation works in the world? The Naviglio Grande, an irrigation, navigation and power canal, utilizes the Ticino River coming down from the northern lakes and spreading its waters over an immense area by means of secondary canals and ditches. The Martesana Canal connects Milan with the Adda River on the East, and the Pavia Canal connects on the south with the Po and the Ticino. The Naviglio Grande is the oldest and the most interesting. It has been a gateway of commerce for over six hundred years. The Villoresi Canal, named from the engineer of that name, who worked hard for many years without avail to get his project adopted, but died before its realization, does not have its head gates at Lake Maggiore, as the Naviglio Grande does, but 15 miles below it, and it runs eastward, watering all the plain to the north of Milan. There is still another interesting canal to the south of Milan, the Vettabia, a private canal, owned and operated by a farmers' association. It is one of the most interesting in Italy. It was once a natural stream made up of three small creeks which came together at what is now the city of Milan, and the old canal or ditch of the year 1150 is now the "interior" canal of Milan and is known as the "Ring Canal," which is around the central part of the city.

The canals of Piedmont are equally interesting from a historical as well as engineering point of view. The principal canal is the Cavour, named from the great statesman who projected and urged it for many years.

About 1850, the government purchased quite a number of small canals, connected them into a comprehensive system and made them subsidiary to the larger project of a main canal from the Po, which, coming across the drainage of the country, would feed and equalize the smaller canals and ditches. This scheme was brought forward by Francesco Rossi of Vercelli and his plan was supported by Count Cavour, the best friend of irrigation Italy ever had, as well as one of the greatest statesmen

of modern times. It was a tremendous undertaking to dam up and divert a great river like the Po and carry it over one river here and under another river there. All the while Italy was struggling with Austria for its independence; its coffers were empty and the wars from 1859 to 1861 delayed the work. Cavour died in the latter year. In 1862, a syndicate of English and French capitalists took over the project, but financial troubles intervened and the company became bankrupt in 1867 and the project was tied up for three years by litigation. The government finally took over the whole work in 1874 after \$10,000,000 had been spent, and it has operated it during the last thirty-eight years. There are many other canals in this section of the country. The whole of the north of Italy is intersected everywhere with canals and ditches, and the works of art are substantial—solid masonry—and are real works of art. (The above facts are based on a personal examination made in April, 1913.)

But we must hasten on to Rome, as all the intervening country is known to you and so, probably, is Rome. It was in Rome that we saw again several of our good friends of the Philadelphia Congress, whom we had welcomed on the docks at New York. They were all exceedingly kind to us. One day, by the entrée given to Commendatore Luiggi at the Victor Emmanuel Memorial now under construction and no doubt in size and grandeur surpassing any memorial monument in the world, we had the good fortune to go with him and the superintending architect to examine it from foundation to the lofty esplanade of the roof, and stand near the great bronze equestrian statue of Victor Emmanuel. I say "great statue" and you will appreciate its size, if you ever have the chance to ascend into it by way of the stairway in the hind leg of the horse and enter his interior, where 27 persons sat at table at a banquet the day of its inauguration.

An interesting engineering matter was brought to my attention by Mr. Luiggi, a recent project, or projects, suddenly brought out by the occupation of Tripoli by the Italian government after the Turkish-Italian war. As soon as the Italian government had secured a foothold there and was confident of holding its ground, it dispatched Commendatore Luiggi to examine the various harbor situations, make plans and set contractors at work. It was all started in an incredibly short time and these ports are now under construction. A map of Tripoli and the Red Sea coast will show you where they are. The plans not only contemplate

protection works, but modern ports and cities with water supply, sewerage, public buildings and all that is needed to make a port prosperous. Not only the port of Tripoli (Fig. 1), but two others on the northern coast are now under construction on Mr. Luiggi's plans and also a protected port on the Red Sea littoral at Massaua. (Fig. 2.)

We were introduced to one of the best known engineers of Italy, Mr. Italo Maganzini, who is the president (chairman) of one of the permanent commissions of government engineers. Mr. Maganzini has recently published an interesting report, or paper, on the subject of the engineering works on the large plain lying south of the River Po, called the Sub-Apennine and extending to the Adriatic at the mouth of the Po from Parma north of Bologna, including Ferrara and Codigoro near the sea. The pamphlet is well illustrated with photographs and hydro-electric works and by a detailed map showing the location of all the works and of the irrigation and navigation canals. (Fig. 3.)

I have said that Mr. Maganzini is chairman of a board. The government's works—railways, roads, and hydraulic works—are supervised by three boards of twelve superior engineers, with their office at Rome in the Ministry of Public Works. All propositions for concessions, all plans for works of all kinds that come before the Minister of Public Works are referred for examination and report to the appropriate board, which meets once a week to consider the subjects referred to it; and once each month, or oftener if called together, the three boards meet as a joint board to discuss and decide upon matters of interest common to all. In this way the work of the department proceeds under the advice of this very competent organization.

Our next visit was at Naples and that beautiful and interesting circuit of travel—Pompeii, where explorations are still going on bringing out treasures of the past; Cava, and that always delightful ride from there by way of Amalfi to lovely Sorrento and the sail to Capri. At Amalfi we visited, as all do, the Hotel des Capucines, where, since I was there in 1898, a slice of it consisting of eight rooms of this old monastery up on the hill, went down in a landslide, but the natural beauty of the place is not injured. The sun still shines bright and the same deep blue waters of the sea are beneath you, the same indented coast line, stretching away in the dim distance, dotted with villages on the steep slopes; and then there is that wonderful highway along the

bluffs toward Sorrento, with the Isles of the Sirens always in evidence. At Sorrento we visited the Crawford Villa, the proprietor no longer there and writing no more his beautiful stories, but the garden and the bold sheer bluff on the rock and the sea lapping its feet is as charming as ever. You will remember that Mrs. Harriet Beecher-Stowe, after a visit here and gathering the historical facts about the lovely girl of her story, wrote that

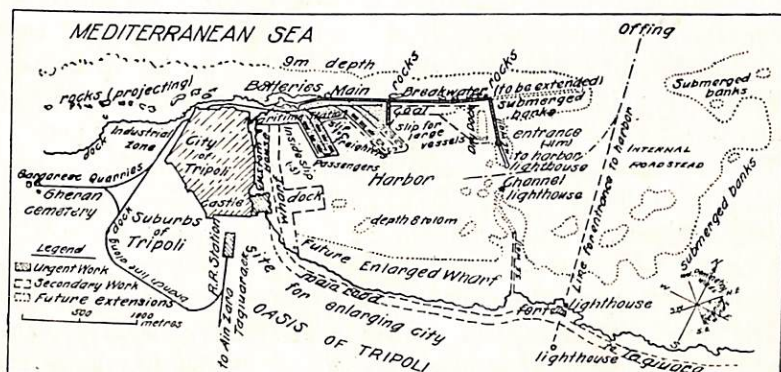


Fig. 1. General Map of Tripoli Harbor.

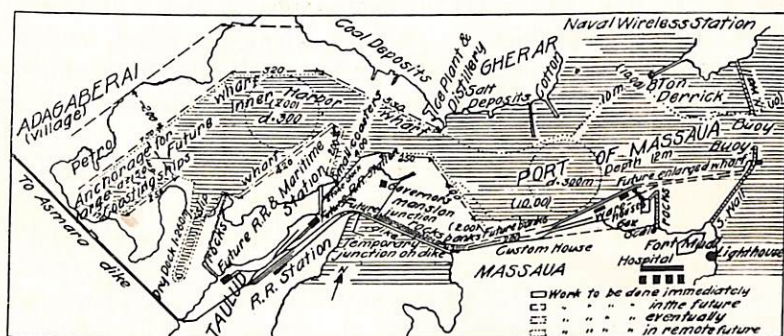


Fig. 2. General Map of Massaua Harbor.

classic, "Agnes of Sorrento," who lived in a house, or cabin, in one of the gorges about Sorrento.

Capri and the Blue Grotto you all know about, and I will not delay you there. We, then, on our return to Naples, sailed for Alexandria on the S. S. *Prinz Regent Luitpold*, of the North German Lloyd.

As we approach the harbor of Alexandria, the interest is enhanced by the facts of history, which all of us from our earliest

youth have treasured up with the abiding hope of some day seeing what we have read about, and possibly this lends a glamour to the land of Egypt, almost the cradle of the human race and a country contended for and possessed by nearly all the races of ancient times, as one after another gained predominance in Europe and western Asia.

We miss the Island of Pharos (as it is now connected with the main) with its lighthouse said to have been 600 feet (180 m.) high—one of the seven wonders of the world. It disappeared long since, destroyed by an earthquake about 1200 A. D., but on a clear, calm day its ruins are still visible in the deep water. It gave its name to all the light-houses since then—"Phare" in French.

The city founded by Alexander the Great in 332 B. C., containing in the First Century A. D. 300,000 population and adorned with palaces of kings and the arts of Greece and the wealth of Egypt and Rome, would scarcely be recognized by the ancient worthies, if they should visit it, for its then distinctive characteristics of royalty, literature and art have largely yielded to the demands of modern commerce, which has spent its energies and its money to prepare a deep and safe entrance from the sea for the largest modern steamers, and a quiet, convenient and well protected port with all of the latest facilities for handling passengers and cargo expeditiously from ship to rail and rail to ship and to send them forward on a first-class railway and equipment, at a good speed, to Cairo.

The entrance channel, until recently, had a depth of only 26 feet (7.9 m.); it now has over 30 feet (9 m.). A breakwater $1\frac{3}{4}$ miles (2.82 km.) long, extending from the southerly point of what was formerly the Island of Pharos, efficiently protects an area of 1,300 acres (525 hect.), of which 800 (325 hect.) have a depth ranging from 30 (9 m.) to 60 (18 m.) feet. Inside there is a solid mole for ships, 100 feet (30 m.) wide, constructed in 40 feet (12 m.) of water and 30 feet (9 m.) of mud, into which the foundation of rubble-stone was thrown. The mole is faced with large quarry blocks on the outside and with quay walls on the inside. With this mole 1,000 yards (900 m.) long and a great extension of walls around the port, there are about $2\frac{1}{2}$ miles (4 km.) of stone quays, accommodating a large number of steamers and coastwise craft. Practically all the facilities of harbor and port—railway stations and railway to Cairo, were the work of English engineers and contractors.

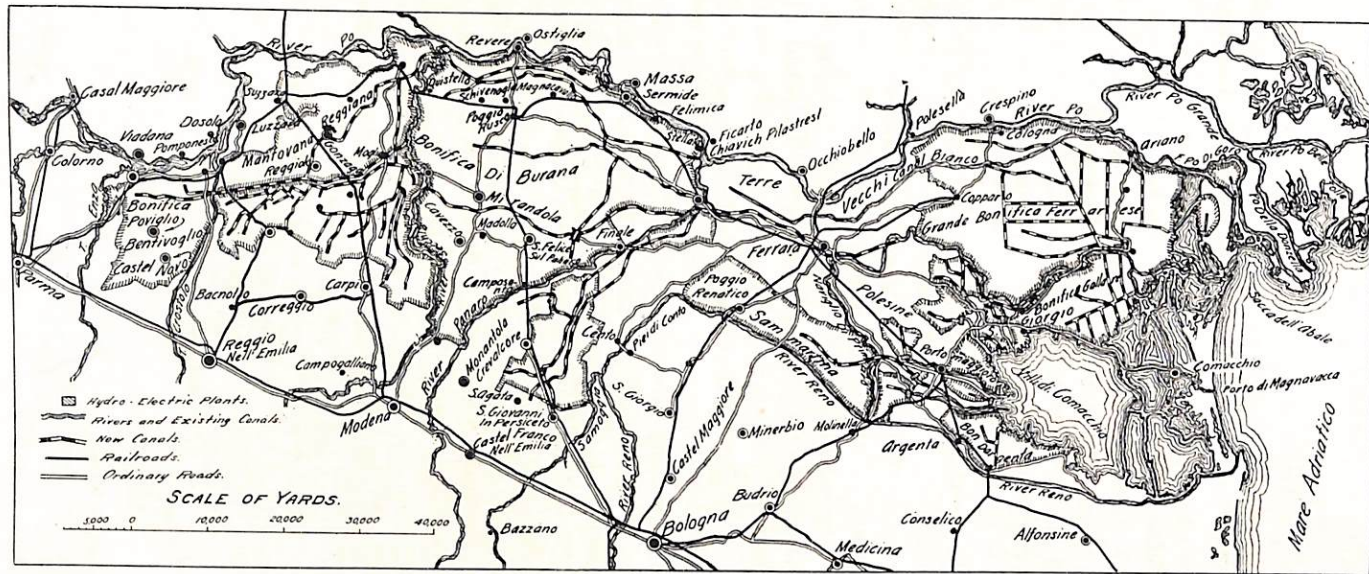


Fig. 3. Improvement of the Sub-Apennine Plain, from the Enza to the Sea.

As I had with me letters to English engineers in Egypt, members of the Institution C. E., sent me as a member of the Institution by Doctor Tudsbery; the Secretary, I was quite sure that my hopes of seeing engineering works would be realized, but I was not quite prepared for the generous attention given me by them, particularly by Mr. C. Carkeet James, Controller General of the Cairo Main Drainage, and Mr. Murdoch Macdonald, Under Secretary of Public Works. As we knew personally Mr. Perrier, Chief Engineer of the Suez Canal, who attended, as delegate of his Company, the International Navigation Congress at Philadelphia, we were quite confident he would do all in his power to show us his important work, and our expectations were more than realized. I should add that Major Tucker, Royal Engineer, engaged in building reinforced concrete barracks for a force of 5,000 soldiers—infantry, artillery, cavalry, and a *camel* brigade—was kind enough to take us over his work not far from Helio-polis, in the suburbs of Cairo, and show us one of the most complete layouts—substantial, convenient, comfortable and admirably arranged, built on the sands of the desert, with well paved streets, walks and gardens, and grass plots and shrubbery started, all well watered and sewered. It is well worth a visit by any one stopping a few days at Cairo. There is much of engineering interest in this city of three quarters of a million, and rapidly growing.

There are three bridges across the Nile. The "Roda Bridge" was built by Sir William Arrol Co.; it is 1,750 feet (535 m.) long, with spans of 140 feet (42 m.). The piers were sunk to a depth of 70 feet (21 m.) below low Nile level, or 92 feet (28 m.) below high Nile. The bridge was built in twelve working months—a good record. A fourth bridge, the "Abbas Bridge," named after the reigning Khedive, is planned on the pattern of the Tower Bridge of London, in order to avoid the interference and inconvenience caused by the existing swing bridges. There has recently been completed, and opened to traffic, the Boulac and Zamalek Bridge between Cairo and Gezira. This bridge was built under difficult conditions, on account of the very considerable depth of water. It was impracticable to build a staging from which to lower the caissons to the river bed or for the erection of the spans. The caissons were hung to powerful jacks supported on two pontons, anchored over the site of the piers

and held there until the caissons were well sunk and stable in the river bed. The spans were built on a staging on shore and floated out to position on two pontoons.

In the official inauguration of this bridge by Sirry Pasha, Minister of Public Works, he referred to the rapid growth and extension of Cairo in recent years. Four years ago the Khedive opened the Roda Bridge, connecting Old Cairo with Gizeh and the Pyramids. Last summer a new highway was opened between Cairo and the baths of Heluan, about 15 miles (24 km.) by a good highway. The island of Gezira, which a few years ago was a rural district, has now a large suburban population. "Old Cairo" is rapidly disappearing and the miserable huts are being removed, the unsanitary situation greatly improved and space given for a new city there.

One of the most important works is that in the hands of Mr. James, which is so novel in its conditions, plans and general situation that it merits more than a brief notice. I may say in passing, that when we went to Assuan by the *Egypt*, one of the latest and largest tourist steamers of Thos. Cook & Son, on a voyage of nearly three weeks, Mr. James, to whom I had presented my letter of introduction, showed me some of his plans and insisted that we should give him a day on our return, to make a personal inspection of the works, which were then in the full swing of construction. We therefore shortened our Nile journey two days, returning to Cairo by night train from Luxor, instead of from Assiut, as we had arranged. This gave us one day for him and one for Major Tucker and then time to get to our steamer, *China*, of the Peninsular and Oriental Co., at Port Said for Marseilles and Gibraltar.

It was a beautiful day for the main drainage examination. Mr. James is one of those engineers who have all details at command, but he has also a corps of able assistants in immediate charge of each work, all of which, however, is under contract, and the engineers of the contractors were on the job, as they well might be, for some of them were struggling with trenches 30 feet (9 m.) deep in running quick-sands; for it must be said here that the subsurface water of the Nile extends to the highland on each side through the alluvial sands, and (a most interesting feature) has a varying slope. As the waters of the river rise, the slope towards the highland steepens and when the river falls, the level near the highlands still continues to rise until at last the slope is

reversed and then the subsurface water next the high lands begins to fall and continues to fall even after the river rises, and then it rises again. The valley at Cairo is about 15 miles (24 km.) wide and yet this movement of subsurface water is always in evidence in wells dug anywhere the entire width of the valley. This phenomenon exists everywhere, even in the delta itself, the head of which is about at Cairo. The length of the delta to the sea is about 90 miles (145 km.) and the width there about 90 miles (145 km.) also. It is therefore a true delta Δ , and yet the entire area is underlain with the percolating water of the Nile, about which we will have something interesting to say later on.

The "Site Plan of the Cairo Main Drainage Works," which accompanies this description (Fig. 4), gives the outline of the project and of the territory traversed, and of the sewage farm of 3,000 acres in the distant desert, about 16 miles from the center of Cairo, and the "legend" on the plan shows the peculiarities of the plans to meet the rather unique conditions and to dispose effectively of the sewage of a population of now over three quarters of a million, most of whom have not been accustomed to modern sanitation. It has been a question with some, whether this rather ignorant people, as many are, can be persuaded to use the modern facilities that are to be forced upon them; but every house, however old and humble, will have plenty of water and the most modern and convenient sanitary arrangements, which will in course of time change the habits of centuries.

Apart from the engineering interest in this locality, there are very interesting historical features which the tourist goes into the desert to examine, and who, travelling along with his Baedeker, no doubt wonders what the purpose is of this deep trench nearby his desert route, where hundreds of Egyptian laborers and batteries of boilers and pumps are hard at work.

As we went along in our comfortable automobiles and train and trolleys—for there is a good highway or track built by the Main Drainage Works the entire length of the line, after leaving the railroad, to the sewage farm—we passed the new barracks of Major Tucker on the right and those of the Egyptian army, the Kubba Palace of the Khedive, with its beautiful grounds, stables, and farms, built by Ismail Pasha for his son Tewfik, and where the Khedive often resides; we pass, about 6 miles (9.7 km.) out,

Mataria, formerly renowned for its balsam plants brought from Judea by Cleopatra, and near by is the new city of the old Greek city Heliopolis, and in the Jewish scriptures "On," which is to be one of the most beautiful suburbs of any city, and where millions are being spent to make it so. Already it has one of the

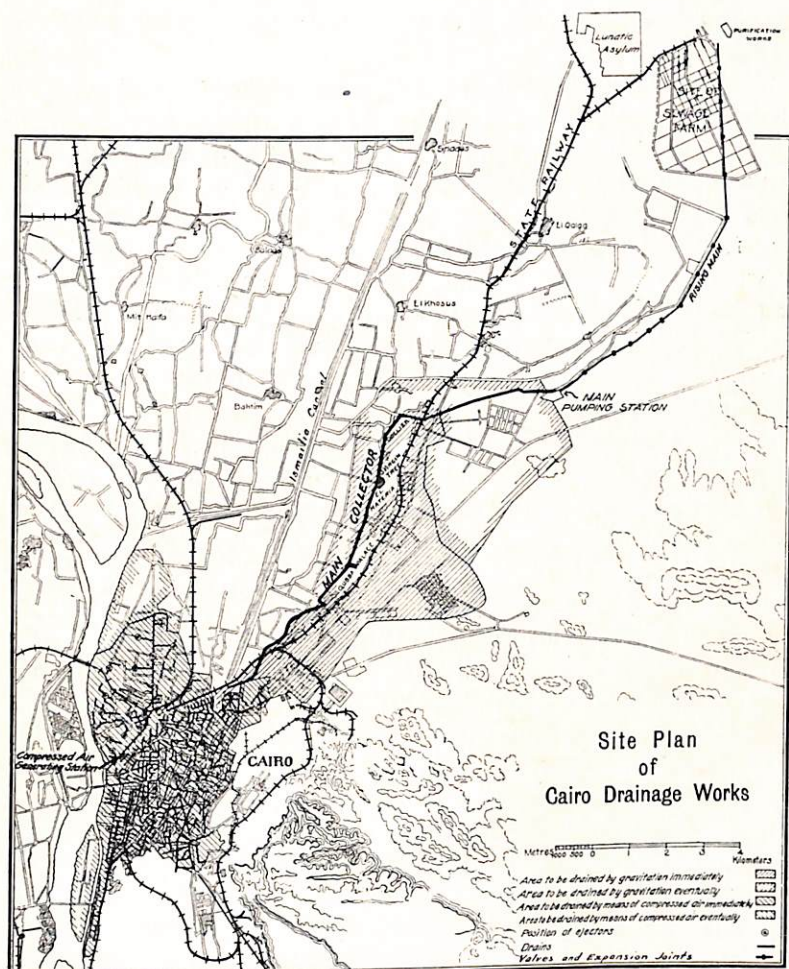


Fig. 4.

largest and finest hotels, and hundreds of artistic and convenient residences, the project of a syndicate, mostly Belgian. Near by is the "Virgin Tree," where the Holy Family stopped on their flight to Egypt. Here is the old sycamore under which, or one of its predecessors, they were shielded from the heat of the noon-

day sun. These old trees have succeeded each other ever since; the one now just alive and propped up was planted in 1672, the former one having died in 1665, and to replace the present one a shoot of it was set out near by and that, too, will in the year 2100, no doubt, be replaced in the same way, so as to mark forever this sacred spot and the old well near by, where Joseph and Mary drank.

We now pass, and so does the Main Collector, near the lone Obelisk, 66 feet (20 m.) high, the oldest in Egypt, built by Usertsen I, "The Son of the Sun God Ra," about the year 2433 B. C. "Has executed this work at the beginning of a thirty years' cycle, He to whom life may be given for evermore," so the inscriptions cut into the Obelisk say, and much more. Its fellows, of which there were several, have been removed from time to time; one to Rome, two to Alexandria, and then one of these to the Thames Embankment, London, and the other to Central Park, New York; so it stands here near Heliopolis the only remaining vestige of Usertsen I, and may he "the son of the Sun God Ra," forgive a sewer with the sewage of his descendents 4,346 years afterwards, going for purification and the fertilization of the desert, miles farther yet, to raise shade trees and garden sauce for a great city. We are not far from another interesting spot, where the "Mounds of the Jews" locate the ancient city of "Onion." From the top is a beautiful view, and the same can be seen from the top of the house of the ostrich farm, which we visited another day, not far from Heliopolis. To the south the Pyramids (Cheops and the others) and Cairo with the Citadel, standing out prominently in the clear cloudless sky, and nearer to us is the lone Obelisk, the palace of the Khedive, and far to the east the range of high hills against the sky. The Jewish historian Josephus says that the son of Onias, the High Priest, fled from Antiochus, the King of Syria, and took refuge in Alexandria in the time of Ptolemy Philometer, about 180 B. C., and got permission from him to build a "temple" like that at Jerusalem," led to do so by a prophecy of the Prophet Isaiah, who predicted that there would be a temple in Egypt built by a Jew. Other Jewish cities were built near here afterwards: They were probably, according to Isaiah, the "five cities of the land of Egypt," which were to "speak the language of Canaan," and now a sewage farm is located among all these relics of a great past and the sewer that brings the

sewage lies beneath and alongside of the remains of the edifices of the ancient Egyptians, Phœnicians, Persians, Greeks, Romans, Jews and Christians, and over these desert plains armies have fought and contended for supremacy, and the hordes of Asia, coming from their far distant countries via the Isthmus of Suez, have swarmed over the country and conquered and were in turn conquered.

The history of this interesting country is so enticing to us that modern works seem almost out of place, but when we know that they are for the great benefit of a populous country, we must forget the past and take up with the always interesting present.

The Site Plan and its notes and the splendid portfolio of detail contract drawings show this interesting work of the main drainage clearer than any written description. It will be seen that a complete system of ejector areas covers the entire city and is to be extended in the future. These ejectors are operated by compressed air from a main plant, on the western edge of the city. These all work automatically as they fill and eject the sewage into the smaller sewers, all of which discharge into larger collectors and these into the "Main Collector," which extends by gravity about 9 miles from the city to the main pumping station, which pumps the sewage to the purification works at the sewage farm, about 7 miles farther out by a "Rising Main."

The Main Collector is circular, 1.6 m. (5.2 feet) in diameter in a mass of concrete with a circular concrete drain below it 1 foot in diameter, laid in and surrounded by rubble-stone.

There are forty-three working plans in all,* which are illustrative of the entire work.

The works, as Mr. James says, are not complete, but they are everywhere under construction. At Khanka (at the sewage farm) the process of raising shade trees in a large nursery is in operation by water from a deep well, operated at present by a large windmill, and it is remarkable how quickly the desert responds to the application of water, just like the deserts of our Far West. They need only water to "blossom like the rose." No doubt, the sewage farm will supply the city of Cairo with most of its garden products.

As I have already said, I have had great interest in the Suez Canal for many years. I find in my "Bibliography of 63 papers

*Not printed.

and books published" No. 16, as follows: "Ship Canals, Johnson's Universal Cyclopedia, Vol. XII, 1886." One of the Ship Canals quite fully described was the *Suez Canal*, compiled from reports and books on the subject, principally Professor Nourse's history, and from considerable correspondence. My intimate connection with the American Isthmian question and many years of study and much writing of reports on maritime commerce since 1886, and particularly in the last two years, investigating and presenting a "Report" upon the "Question" before the Philadelphia Navigation Congress: "Dimensions to be given to Maritime Canals, taking into account the probable dimensions of ocean ships of the future," and in which I discussed the increasing depth and dimensions of the Suez Canal—all this naturally gave me a strong desire to examine it under the direction of its chief engineer. The results of this examination will be given a little later.

Reviewing a little of what I wrote many years ago, let me say that like the American Isthmian projects, efforts partially successful characterize all the past, and the hopes of commerce have centered upon the two isthmian problems, and both will soon be solved. The ancient attempts at Suez confined themselves to a connection between the Red Sea and the Nile, and what was left of one of them is now the "Fresh or Sweet Water Canal," from the Nile to Ismailia and thence to Suez and Port Said, which gives the existing main salt water canal its sweet water for domestic and potable purposes, supplying the three principal cities and all intermediate points. It is appropriate here to remark that at each of the three cities there is an adequate plant, filtering basins, pumps and reservoirs, and water as pure as any in the world. At each installation we examined the water, and at Port Said, where the service, which furnishes not only the city and the canal works but also passing steamers, is in charge of a superintendent who is a chemist, the record shows that water delivered to consumers contains not more than 6 microbes per cubic meter (35 cubic feet). If more appears by the analysis, that basin is drawn down and cleared out. The water in the first basin (there are eight in all), as it comes from the canal, contains less than 125 microbes per meter, and yet on the main Nile, where there is an immense volume of running water under the purifying influence of sun and air and

wind, we are told to drink special table water, because Nile water is unhealthy.

But to go back into the past history of the canal. On the north wall at Kanak, near Luxor, is a scene of the time of Seto I, 1366 B. C., showing his triumphant return from Asia by way of "The Cutting," which probably communicated with the Nile, as crocodiles are seen in the hieroglyphics. Necho II, 612 B. C., who defeated Josiah, King of Judah, built a canal which tapped the Nile at Bubastis (the Pibeseth of the Bible) on the west bank of the Pelusiac branch of the Nile, the mouth of which is *east* of the present ship canal. Necho's canal reached to near the present town of Zagazig and follows almost the line of the present Wadi Canal to Heliopolis. In those days, the Red Sea extended much farther inland than now; also the delta of the Nile since then has stretched farther seaward into the Mediterranean, so that it is not easy to locate the work of these ancient worthies. Darius, one hundred years after Necho, cleaned out this canal, badly silted up, and made it navigable for the boats of those days, so that the passage between the two seas was made by sailing up the Pelusiac branch of the Nile to Bubastis and along the canal to Heliopolis, where the cargo was transhipped to Red Sea vessels. The next Egyptian king, Ptolemy Philadelphus, about 285 B. C., again cleaned out the canals and put locks in at Heliopolis, but which prevented the salt water from mingling with and spoiling the fresh water. But, as the Nile thereafter almost entirely deserted the Pelusiac branch, this route passed into a state of desuetude, for, in the reign of Cleopatra, 31 B. C., it was impassable. There is not much more to say for this route, though it is said that in the year 1000 A. D. it was opened up again, but after that it was choked up with sand and neglected. In 1571 the Venetians, who then had a monopoly of the trade with the east, began negotiations with the Sultan of Egypt, but they were stopped by the Turkish invasion of Egypt, after which all idea of a canal was given up. In more modern times Napoleon Bonaparte undertook the investigation of an interoceanic canal, and he himself examined the old canal of Necho and his successors and ordered Monsieur Lepère to make a survey. He reported a difference of level of *30 feet* (9 m.) between the Red Sea and the Mediterranean, which, of course, would make a maritime canal without locks impossible. In 1846 a mixed com-

mission, including George Stephenson, was appointed to examine into the practicability of a canal. They exploded Monsieur Lepère's old error, but they came to no conclusion. Then came on the scene Ferdinand de Lesseps. A project was drawn up under his supervision by Messrs. Linant Bey and Mougel Bey, under a concession from the Viceroy of Egypt, Said Pasha. This project was submitted to an international commission in 1856, comprising representatives from Austria, England, France, Italy, the Netherlands, Prussia and Spain. The project, modified by this commission, was accepted and successfully carried out, as we all now know.

It is unnecessary to give its history. In my "Report" to the Philadelphia (1912) Navigation Congress (alluded to above), I traced the successive enlargements in the project of a ship canal on the American Isthmus, due to the increasing size of vessels. This happened on all the routes proposed and I had the following to say about the Suez Canal, which is apropos at this point in this communication:

The Suez Canal has also had many vicissitudes and a constant development due to the commercial requirements. The steamships have been obliged, greatly to the detriment of trade, on the long course from Western Europe to the Orient, to keep their dimensions at a minimum—especially their draught—but the insistence of commerce has continually forced the canal company to make greater dimensions.

No doubt the competition of the Panama Canal, with its much larger dimensions, will compel the Suez Canal Company to give to commerce what it requires—so that competition will redound to the benefit of the whole world.

It may not be generally known that as long ago as 1855-1856 an International Commission reported that the depth should be 8 m. (26.2 feet) and the width 64 m. (210 feet) at the bottom and 97.5 m. (320 feet) at the surface of the water for two lines of vessels in movement and a third line tied up at the bank, between the Red Sea and Bitter Lakes; and between there and Port Said 43.9 m. (144 feet) at bottom and 79.8 m. (262 feet) at top, but in 1862 these, for that period generous, dimensions, were, on account of finances, unfortunately reduced to a width of 22 m. (72 feet) bottom width, much to the detriment of the world's commerce for many years.

The Canal was opened to traffic in 1869 with these dimensions—but there was a continual demand for greater depth. In 1884-1885, the International Commission recommended a *final* deepening to 9 m. (29½ feet) with 65 m. (213 feet) width from

Port Said to the Bitter Lakes and 75 m. (246 feet) from there to the Red Sea.

In 1899 this "final" depth of 9 m. was reached, but then commerce still needed more, and it was decided to make it 9.50 m. (31 feet). Then the consensus of opinion demanded 10 m. (32.8 feet), and still there was not sufficient depth, and now the final (?) depth is to be 10.50 m. (34.5 feet).

Regardless of the fact that the canal—in spite of its physical restrictions upon commerce—was earning enormous dividends, it has required constant urging to induce the company to hasten its work and give trade a freer passage.

The following, stated by Sir John Wolfe Barry at the Engineering Conference, London, in 1907, confirms the above statement: "I happen to have been on the technical Commission of the Suez Canal for many years with my friend Sir Charles Hartley and we—the British representative engineers—have persistently, year after year, in season and out of season, for the last fifteen years, urged upon the authorities of the Suez Canal the extreme importance of deepening the canal to the depth which is now nearly realized, of 10 meters."

Evidently the English engineers on the Commission can not be criticised for the delay in making the channel more adequate, and from our knowledge of the French engineers, the same may be confidently said of them.

In the author's opinion neither 10 nor 10.50 nor 11 meters will suffice. He believes that within a few years this canal will necessarily have to be deepened, in order to retain its traffic, to 13 meters (42.6 feet), at least—allowing for a draught of 12 meters (39.4 feet) with corresponding width to allow for the passage, in two lines, of vessels of 25,000 tons.

Note the gradual and evidently reluctant concessions to the steamships in the matter of draught. The company authorized in 1869, 7.5 m. (24.6 feet) draught; 1890, 7.80 m. (25.6 feet); 1898, it widened the canal from 22 m. (72 feet) to 37 m. (121 feet); 1902, 8 m. (26.2 feet) draught was authorized; 1906, 8.23 m. (27 feet); 1908, 8.53 m. (28 feet), the canal having been deepened to 9.50 m. (31.2 feet), and 8.53 m. (28 feet) was the authorized draught in January, 1911.

With the above in mind let us see what we found by our personal examination. From the profile and sections handed to me by Mr. Perrier, Chief Engineer, after finishing the examination of the Canal on January 25th last and the new programme of improvements of the works decided upon at the reunion of the International Commission in 1912, it is seen that provision is made for a depth of 12 meters (practically 40 feet) everywhere, with a minimum or standard width at the bottom of 60 m. (197

feet). As it has been found necessary to allow a depth of 1 meter under the vessel when moving, the draught can then be 11 meters (36 feet). Comparing this uniform depth of 12 meters with depths at Panama, we find at the latter canal the following as the final depth: Limon Bay to Gatun Locks 41 feet (12.5 m.) at mean tide, range of tide $11\frac{1}{2}$ feet (46 cm.) or at mean low tide 40.3 feet (12.3 m.) In Culebra Cut 45 feet (13.7 m.), over the lock sills 40 feet (12 m.). The tidal fluctuations at the Suez Canal are practically nil on the Mediterranean side, depending upon the winds. On the Gulf of Suez, and also depending largely upon the winds, the difference may be assumed at about 3 feet (0.9 m.), so that at times the depth will be $38\frac{1}{2}$ feet (11.7 m.) but generally the difference of levels is inconsiderable, so that the two canals will have about the same usable depth.

I am very glad indeed to say that the able International Commission, all of whom are competent to appreciate the requirements of commerce, have not only decided upon 12 meters (40 feet) depth, but have been able to persuade the canal company to accept their conclusions. Twelve meters is a great deal better than the 10.50 meters stated by me to be "final" in March, 1911, when my "Report" to the Philadelphia (1912) Navigation Congress was finished. There is no question in my mind of the ability and policy of the International Commission, and the company as well, to keep abreast of the times and up to the requirements of commerce. Not only is the depth increasing but the alignment is being improved, the under-water slopes in many places are being flattened and the foot of the slopes at the water line is being protected (see Fig. 5), and at Port Said a radical change in and enlargement of facilities is now being carried out at a cost of 15,000,000 francs (\$3,000,000). All the facilities, including the fleet of dredges, tugs, boats, etc., of the company and all of the repair shops will be concentrated on the east side on an area of 800 meters (2,624 feet) wide and 2,500 meters (8,200 feet) long, on ground reclaimed from the sea by means of a substantial sea wall and filled behind with sand, pumped over by hydraulic dredges. There will be dry docks, slipways and smaller cradles, a complete electrical equipment of three 600 H. P. motors, shops of all kinds, storehouses and offices, all substantial structures of brick, stone, concrete and reinforced concrete, and an abundant supply of fresh water by means of submarine pipes from the water works on the west side.

Some of my pencil notes taken on the examination of the canal are of interest. The company has one floating crane of 60 tons, one of 40 and one of 35 tons. It has at work twenty dredges of various kinds and two Lobnitz rock breakers, the breakers weighing 20 tons. The dredging contractors have four dredges. Widening according to the programme is going on in many places. The canal and sea approaches are well lighted by Pintsch gas

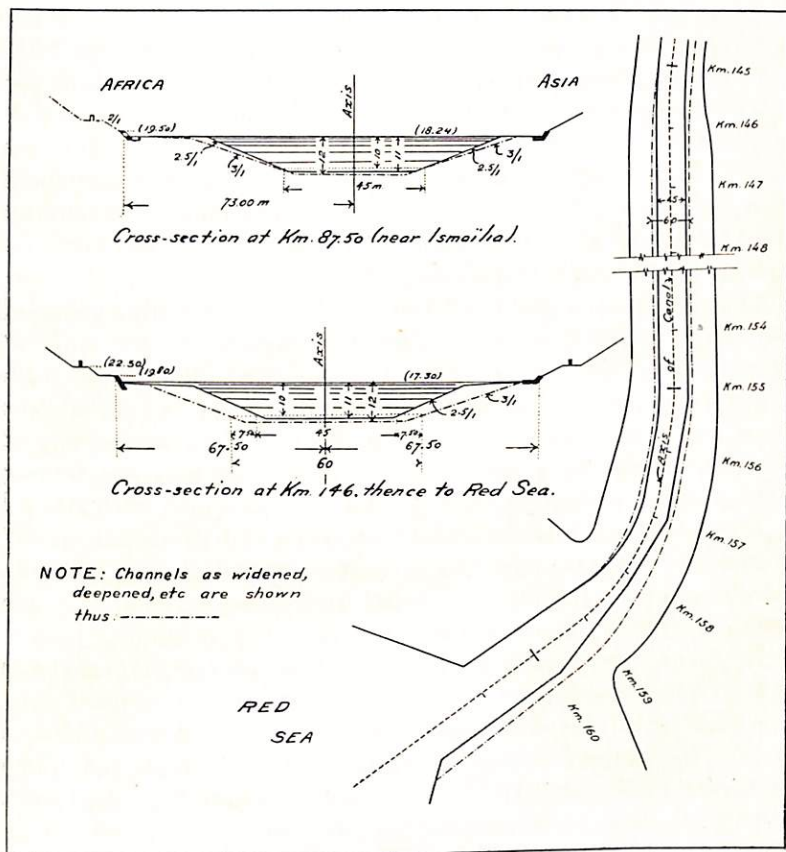


Fig. 5. Suez Canal. Typical Plan and Sections showing widening, deepening, etc., under way.

buoys. There are many day and lighted beacons on land and on pile platforms at the wide places and in the Bitter Lakes where necessary. The least radius of curvature now is 2,500 m. (8,200 feet). There are fifteen observation stations along the canal, provided with telegraph and telephone. Every ship that passes through is reported to the principal office at Ismailia as it passes

the observation stations, and on a diagram at the main office the name of the steamer and of its commander and its tonnage are plotted, as well as the time of any stoppage. This diagram looks very much like the train sheet of a railroad or the Marconi sheet on shipboard, showing steamers going in reverse directions. By this means every incident of the passage is known at the head office. The allowable speed is 10 km. (6.2 miles). The average annual cost of maintenance is 5,000,000 francs (\$1,000,000) and of construction work 6,000,000 francs (\$1,200,000).

It is unnecessary to state that the jetties at Port Said have been extended and that they protect the entrance against the storm waves and that the approach at the Suez end, where scattered shoals exist, is well lighted by a light-house and numerous lighted buoys. The width of the two channels between these lighted shoals, the inner and outer, are 300 m. (984 feet) and 375 m. (1,230 feet), respectively.

The income and traffic of the canal are constantly increasing. During the last year, regardless of lowering the rates (now 6 francs or \$1.20), which cost the company 10,000,000 francs (\$2,000,000), there has been a notable increase in revenue and tonnage, and no doubt the enlargement of the canal now going on, permitting the transit of steamers of much larger tonnage, will greatly augment the paying tonnage and lead to further reductions in canal dues. The income in 1912 was 135,720,000 francs (\$27,144,000), an increase of 1,710,000 francs (\$342,000) over that of 1911. The net register tonnage was 20,275,120 tons, being 1,950,326 tons over that of 1911.

In closing the Suez Canal part of this address, I wish to say that I found nothing to criticize, everything to commend, and I am glad to retract what may have seemed to be a complaint of indifference in my paper presented to the Navigation Congress at Philadelphia in 1912. "Familiarity has not bred contempt," but esteem and confidence in the pronounced policy of enlargement of the facilities for the commerce of the world.

THE NILE.

After all, *it* is the "Mecca" of all travellers. Cairo, comparatively modern, is interesting. Its sanitary works, already described, arrest the attention of an engineer; the Suez Canal also; but when we get on the Nile we are in Egypt of old and we do not wonder that the Nile was worshipped or that it was the

maker and benefactor of all the races that have inhabited its valley and lived by its waters. It certainly is unique among all the rivers of the world, in that it never ceases its flow through the desert sands, though for a thousand miles no rain nourishes it, and this gives to it something mysterious, and to its inhabitants it is something sacred. As we travel upon it and daily visit the temples and tombs of departed kings, priests and great men, see their methods of building, begin to understand why the great built their tombs in the living rock, generally far away from the alluvial lands, and gaze into their sarcophagi and sometimes upon the king or priest himself, and go down into the tomb—as of Seti I, passage after passage, room after room, until finally where Belzoni in 1817 found him—and other tombs 300 feet down into the rock; and then look at the great pyramid of Cheops near Cairo and wonder why all this costly work was done, we learn that their belief that there were two natures in every man, one the body we live in, the other his “Ka” or double, who visits the body after death, led them to be extremely careful about this body. The central idea was to hide it effectually from any possible disturbance and to supply it with suitable offerings, and, as the “Ka” could not visit the places where it lived on earth, there must be provided pictures on the walls of the tomb that would show it what it did and had and saw in its earthly life, so that it would feel “at home” when it came to visit the preserved body; and when we see in the Cairo museum the body of Seti I and especially of Rameses II (The Great) and see his uplifted arm, as if giving his royal command, we begin to respect the motives of these great men that could and did do such remarkable things in their lives, and to cease from our smiles at their singular beliefs about the future life.

The voyage up the Nile in one of the comfortable tourist steamers, where all the conveniences of the best ocean steamers are ours, with the daily visits on shore, the exhilarating donkey rides in the clear, cool air of the morning, the examinations of temples and tombs and the companionship of your fellow passengers and the perennial sunshine, then the return to the boat, appetites whetted for a good luncheon, which you will certainly get, the bartering with the natives who line the bank at every town with all sorts of native products; then the sail along the banks, watching the “shadoofs,” as the half-naked Egyptian fellaheen work the well-sweeps, raising the Nile water by some-

times five successive sweeps up perhaps 20 feet from the water into the surface ditches of their fields; meeting the "feluccas" (sailing boats) and the steam and sailing dahabeahs, finding everywhere on the trip of nearly 600 miles (966 km.) from Cairo to Assuan always something new and interesting, and wherever we are, on board or on shore or in temple or tomb, we know that Rachid, the "All knowing" principal dragoman, can answer all our questions and can tell us things of the greatest interest that we can not find in the guide books—all these things make it worth while to spend several weeks on the Nile.

These principal dragomans are wonderful men, know all the languages, have travelled nearly everywhere in the world, read and study between tourist seasons and keep abreast of all new discoveries. They are gentle, courteous, clear in statements, treating all respectfully, listening to all questions, however silly, and dispensing their wealth of information prodigally and never wearying of our importunities. The native, be he Mussulman or Christian, Arab or Copt, is intelligent and trustworthy and even the "donkey boys" who escort us on the excursions are kind and faithful fellows, and we can but admire the trim, supple, soldierly police of the Government Camel Brigade who, one, sometimes two, accompany every party on the excursions to see that the crowd of donkey boys and the people of the villages do not molest or annoy us and to keep all in order.

But all this you can read about anywhere. I am more desirous of telling you something of the Nile and its hydraulic and irrigation features and give you the information obtained at first hand from the English engineers whom I met, and who gave me freely all I asked for. Let me here tell you who they are, as you may meet them if you ever make a trip to Egypt—Mr. Murdoch Macdonald, M. Inst. C. E., C. M. G., now Under Secretary of Public Works, formerly the engineer of the Nile reservoir at Assuan, but now in the Department at Cairo and in charge, with other matters, of the important delta drainage works which I will tell you about a little later; Mr. David A. Watt, engineer in charge of the Nile reservoir; Mr. E. Lambton, engineer at the principal administration office at Assiut, and Mr. McClure, the engineer of Messrs. John Aird Co., contractors, and who had charge of nearly all the work done by them, which com-

prised the Assuan, Assiut, and Esneh barrages. Briefly, now, the main hydraulic features of the river.

The sources are Lake Victoria Nyanza (which means "lake"), Lake Albert Edward and the Abyssinian Mountains. Lake Victoria, the farthest south, is near the equator in the region of perpetual rains, the longest and most southerly tributary of the lake being the Kagera River. Counting in the lake and this river, the total length of the Nile is about 4,000 miles (6,440 km.), which probably makes it the longest river in the world, although its maximum discharge can not compare with those of the Mississippi or the Amazon; all of which are respectively and approximately 500,000, 2,000,000 and 5,000,000 second-feet. Strictly speaking, the Nile is formed by the junction at Khartum of the White Nile coming from the lakes and the Blue Nile from Abyssinia, and still farther north the Atbara. Below this point there are practically no more tributaries in its course of 1,600 miles (2575 km.) to the sea, which makes the river phenomenal. As to altitudes, Lake Victoria, 3,700 miles (5955 km.) from the sea and in area 25,000 square miles (65,000 km.²)—larger than any of the Great Lakes of North America, Superior excepted; Huron has 23,200—is 3,672 feet (1,120 m.) above sea level. Lake Albert is 3,350 miles (5,390 km.) from the sea and its elevation is 2,250 feet (686 m.). At about 2,700 miles (4,345 km.) from the sea the river runs at a very small slope and it is here that is found the great obstruction of the "Sudd," a vegetable growth often very extensive, and the river becomes a swamp. One is reported as three-fourths of a mile long, perfectly firm and overgrown with high reeds and grass. The graves of people who had died of the plague were actually upon it. The Nile plunges under them by a subterranean channel, roaring like a cataract. These obstructions receive accretions of other floating islands which drift down to them. There have been found upon them trees and dead crocodiles and hippotami. This "sudd" is met with over a stretch of 250 miles (403 km.). The English government has endeavored at considerable expense to make a channel through the various sudd. A party of 700 men and four officers and four steamers in 1899 were sent up to remove nine blocks of sudd. It was temporarily removed then and a channel opened. Recently systematic attempts have been made by dredging, and Mr. A. W. Robinson, of Montreal, has two of his dredges at work there.

The most important characteristic of the Nile, outside of its long course without tributaries or rain, is the alluvium which it brings down to fertilize the desert lands of Egypt. The White Nile brings down a fine, whitish clay, hence its name. But the Blue Nile and the Atbara are really the builders of Egypt. They bring down from the Abyssinian Mountains the rich mud, volcanic dust, which enriches annually the millions of acres by the inundations. It has been well said that "Egypt is the gift of the Blue Nile and the Atbara." The Blue Nile is 960 miles (1,546 km.) long, and the Atbara 700 miles (1,127 km.).

The ancient Egyptians kept a careful record of the height of the Nile flood by means of "Nilometers" at Philæ, just above the Assuan dam and now in the reservoir formed by it, on Elephantine Island, opposite the town of Assuan, below the rapids at Kanak, at Edfu, Esneh, and on the Island of Rhoda at Cairo. These generally comprised a well in which was a pillar marked off into cubits, and at the bottom an opening into the Nile. The pillar at Rhoda was divided into 17 cubits of about $21\frac{1}{2}$ inches (55 cm.) each; the 10 upper ones divided into 24 digits each. The walls of the building are decorated with inscriptions, and there are also passages from the Koran relating to the "water sent by God from Heaven." When this Nilometer was constructed, a reading of 16 cubits meant the level at which flood irrigation could be assured everywhere. The level now is $20\frac{1}{2}$ cubits, the difference showing the rise of the river bed, which amounts to about 5 inches (13 cm.) in one hundred years, or about $1/16$ inch (1.6 mm.) per annum. From measurements at the Elephantine Nilometer the rise is about 3 meters, say 10 feet above the bed 1900 years ago, or about $6/100$ inch (1.5 mm.) per annum. This Nilometer is very interesting. Plutarch says that the Nile rose on it to the height of 28 cubits; and at Edfu there is an interesting text which states that if the river rises 24 cubits $3\frac{1}{2}$ hands at Elephantine, it will water the country satisfactorily. On this Elephantine gauge there are scales in Arabic and Greek and on the stairway Greek inscriptions, dating from the reigns of several Roman emperors, giving the year of their reigns and the high water mark of the Nile. There is evidence that the readings of the gauge during the rising river were communicated to the people below, so that notice of the coming flood was circulated. This was before the days of the telegraph. *Now* the engineers at Assuan and Assiut and Cairo receive telegraphic reports

daily from all up-river points as far as Gondokoro, 1,070 miles (1,722 km.) above Khartum, or 2,870 miles (4,621 km.) from the sea, and I saw on Mr. Watt's profile at Assuan the stage that day at all points, so that by this profile they know just what to expect as to height of the floods and the time of the same and the volume of water coming down, and can figure out mathematically and correctly how much water they must let through the sluices for irrigation.

We now come to the crux of the whole situation. Why were the four great barrages built? At Assuan, the largest and for a reservoir; Assiut, to turn some of the water coming down from this reservoir into the Bahr Yusuf (Joseph of the "coat of many colors"), now called the Ibrahimiya Canal on the west of the Nile, which is a *perennial* canal, and Esneh which supplies water to its canal in flood seasons and regulates it and this is called an "inundation" canal, since during low Nile it is dry, the bed being 6 or 7 feet (1.8 to 2.1 m.) above the level of low Nile. The summer crops of Egypt require water during the two or three months of low Nile, but nothing had ever been done until late years to supply this water, and even in modern times the delta was the only part where there was any attempt made to hold the water up and distribute it over the land. From time immemorial the Nile had been let alone to water the land of Egypt according to its own sweet will and annual caprices, and there are no records to show that there was by any ancient ruler any really serious effort to regulate the supply of water by dams and reservoirs, although there are indications that Mena, first king of the first dynasty 4,000 years before Christ built a great dyke at Memphis to control the flood and provide "basin" irrigation, which caused Egypt to flourish and become great. The deterioration of those great works led to the downfall of Egypt's greatness. Napoleon I saw the necessity to the delta of regulating the supply to the Rosetta and Damietta outlets, so as to let the whole flow first down one branch and then down the other, and in 1833 Muhammad Ali blocked the head of the Rosetta branch by a stone dam to throw the water into the Damietta branch, wherefrom, then, all the large canals of the delta took their supply. But this worked mischief to Alexandria and the eastern delta as well, and a dam was built across the head of each branch, but much bad work was done, through no fault of the engineer, Mougél Bey, who was unable to control his master, who insisted that

so many tons of concrete should be dumped every day into the foundations, whether or not the river was flowing over it. Naturally, the cement was all washed out and the bare stone of the concrete alone remained. However, the barrages were completed in 1861 on Mougél Bey's plan. These works are the famous barrage. They are 14 miles north of Cairo. The Rosetta Barrage has 61 arches or openings and two locks, and is about 1,500 feet (450 m.) long. The Damietta Barrage has also 61 arches and 2 locks and is about 1,730 feet (520 m.) long. The repairs which became necessary later led to a restoration in 1886-1891. These barrages can hold up a head of 13 feet. Poor old Mougél Bey, upon whom the Egyptian government visited the sins of his master, Muhammad Ali, was broken down with grief and almost starvation. When Sir Colin Moncrieff was planning the restoration of the barrage, the matter was brought to his notice, and he left no stone unturned until the government gave Mougél Bey an adequate pension, which placed him beyond reach of want.

This barrage is doing good work, but more water was required for the cotton crops of the delta, and the entire valley above Cairo all the way up to Assiut must have water regularly and when needed, for it is well known that some of the most important crops of Egypt can not stand a ten days' drought. The engineers studied the entire situation and all of its peculiar conditions and decided that the necessary supply of water, and at the times needed, could best and only be obtained by making a reservoir by a dam across the granite bed at Assuan. But after the plans were submitted, financial difficulties appeared by the Sudan Rebellion and the project was put aside. But there were men who saw clearly the immense increase in agricultural prosperity that an adequate reservoir of water to use at the proper time would bring about, and among these few men was Sir Ernest Cassel, who in 1898 arranged for the money to build the Assuan dam. He selected the late Sir Benjamin Baker as his consulting engineer and Sir John Aird & Co. as contractors, who undertook to complete the dam and the Assiut Barrage by December, 1903. The Egyptian Government, by the advice of Sir William Garstin, accepted the offer. The work was started in 1899 and completed in 1902, a year in advance of the time agreed upon.

The dam as originally designed would have submerged, for several months each year, the temples on the Island of Philæ, just above and within the area of the reservoir, and such was the

opposition to it by the antiquarians that the plans were modified and the height reduced. But, in 1904, it became apparent that the dam must be raised for the prosperity of Egypt, and the "heightening" was begun in the winter of 1907. The original storage capacity was 34,610,000,000 cubic feet (980,000,000 m.³) of water, but the completed dam stores 88,224,000,000 cubic feet (2,500,000,000 m.³) by the increased height of about 25 feet (7.6 m.). The constant supply of water, over two and a half times that of the original dam, does away with the ancient system of basin irrigation, which irrigated only a part of the year, and the cultivation of the fertile lands of Egypt can go on all the year, furnishing as it does *perennial* irrigation. When it is known that 140,000,000,000 cubic feet (3,964,000,000 m.³) of water could profitably be used in bringing new and reachable areas of Egypt into cultivation, it will be seen how much yet ought to be done and must eventually be done to meet this demand of Egypt. How this increased amount is to be obtained is a problem, the solution of which can not be long postponed. No doubt, more reservoirs will be established at suitable points between Assuan and Khartum. With a sufficient amount of water at command and much of it still wasting into the sea, doing no one any good, it would seem that the brains and the money should be found. The brains are there, I am sure, for no one can examine the splendid work already accomplished by the English engineers without having entire confidence in their ability to cope with this new and possibly more difficult condition. Since writing the above, reports have reached me that another dam between Assuan and Khartum is proposed.

From the engineers I learned the following about what is called the "heightening" of the dam (and while it has, no doubt, been described in the engineering periodicals and you are therefore fully informed about the work, it seems appropriate to give a brief résumé of a rather unusual work). Sir Benjamin Baker insisted upon the thickness on the back of the dam being the same as the additional height; that is, about 5 meters (16.4 feet), also, that, as the original dam had passed through its expansion and contraction period and from green to hard masonry, it would be necessary to leave an open space of 6 inches (15 cm.) between the new and the old work until the former had accommodated itself to the effects of the large variations of temperature and had got itself into the same permanent condition as the old

masonry, and then to fill up the space solidly with Portland cement grout. This was done; and to hold the new work out from the old wall evenly and to hold it up, a plan was designed of inserting steel rods into the old masonry. These can be plain-seen in Fig. 9. The addition to the dam is about equal in volume to the original dam. This dam allowed for a larger freeboard than experience had shown to be necessary, so perfect is the control of the mass and height of the water impounded, so that, by reducing this freeboard, 25 feet (7.6 m.) of additional water height was safe-



Fig. 6. Assuan Dam. Showing West Channel Work in May, 1901.

ly obtained. Another interesting feature which developed was the action of the enormous velocity and impact of the water discharged through the sluices upon the rock below the dam and even upon the sides of the sluices, which showed considerable wear. They were then lined with cast iron. A new talus below the dam 100 feet (30.5 m.) to 200 feet (61 m.) wide and of very considerable thickness in some places to make it of uniform height, was built of Portland cement concrete and granite at a cost of \$1,500,000 (7,500,000 frs.). This talus is divided by cross walls perpendicular to the axis of the dam to facilitate inspection.

Raising the dam made it necessary to change the navigation locks. The height of the walls of the four original locks has been increased 14 feet (4.3 m.) to 21 feet (6.4 m.) and a fifth lock has been added at the foot of the flight. The highest gates, which are the new ones at the uppermost lock, are $84\frac{1}{2}$ feet (26 m.) high, weighing about 200 tons. They are rolling gates, not rolling on sills, but on a girder that runs out with them from the recess. They are worked by hydraulic power at a pressure of about 800 pounds per square inch (56 kg. cm.). These

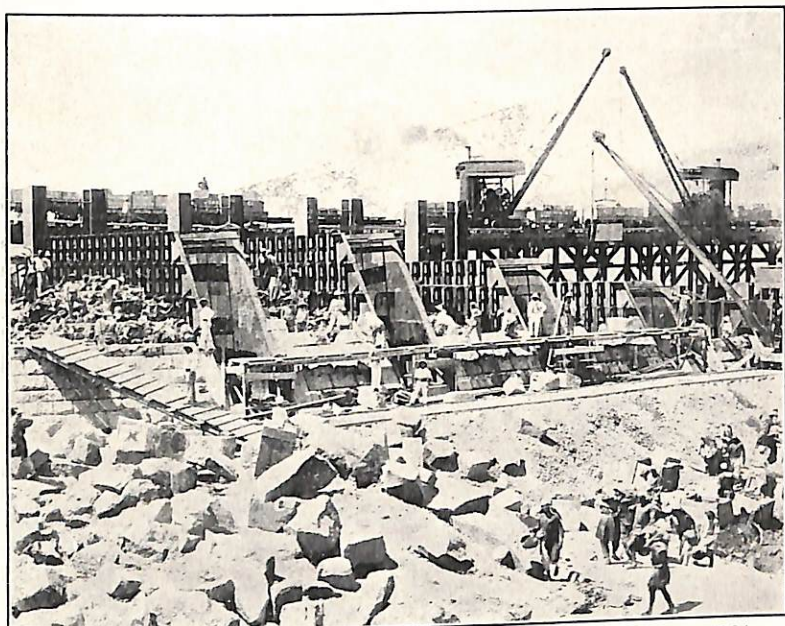


Fig. 7. Assuan Dam. Showing West Channel Work in June, 1901.

gates are designed to withstand a pressure of about 3,000 tons, when the reservoir is full and lock No. 1 is empty. This gate was operated for our benefit by Mr. Watt and his assistant. (These gates and machinery were furnished by Messrs. Ransomes & Rapier. The photographs, snap-shots of ours, show the mechanism fairly well. See Figs. 13 to 15.)

To summarize the changes made in the dam, which was inaugurated on December 23, 1912, by the Khedive and Lord Kitchener, who read a message of congratulation from King George; the following are the principal dimensions of the old and the raised dam:

	As built.		As raised.	
	<i>Feet</i>	<i>Meters</i>	<i>Feet</i>	<i>Meters</i>
Level of water above sea level-----	348	(106.1)	370.73	(113.0)
Pierced portion, width at top-----	23	(7.0)	36.1	(11.0)
Pierced portion, width of roadway-----	16.4	(5.0)	29.5	(9.0)
Solid portion, width at top-----	17.8	(5.4)	30.8	(9.4)
Solid portion, width of roadway-----	11.2	(3.4)	24.4	(7.4)
Storage capacity-----	<i>Cubic feet</i> 34,610,000,000		<i>Cubic feet</i> 88,224,000,000	

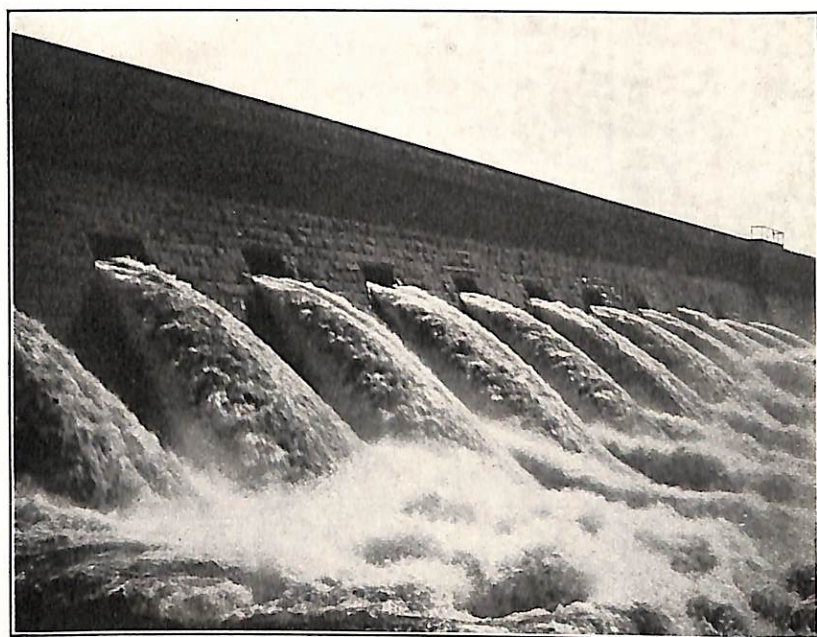


Fig. 8. Assuan Dam, showing Sluices. March, 1908.

On my way up the river certain questions to ask Mr. Watt were noted and sent on to him in advance. These he transmitted later to Mr. Lambton at the principal administration office at the Assiut Barrage and inlet to the Ibrahimiya Canal, answers to which have now been received and are given below as interesting data.

The difference in height of water surface at Assiut in low summer level and floods is 20 feet (6.1 m.). The summer level is affected by the regulating barrage in the river and in the canal nearby. Formerly it was 30.7 feet (9.4 m.). The area of the river section is 98,000 square feet (9,100 m.²). The slope of

the flood surface is 1/11,800, velocity of current in flood is 4 feet per second (1.2 m.), maximum discharge is 448,000 second feet (12,687 m.³). The gates are not down in high flood, the whole volume passing through.

The Ibrahimiya Canal. Width at bottom is 180 feet (54.9 m.); depth in floods is 31 feet (9.5 m.). The bed level of the canal is the same as that of the barrage. Slope of water surface in the canal is about 4.8 inches per mile (7.6 cm. km.). Length of canal to its entrance into the Fayum, 224 miles (360 km.). At this



Fig. 9. Assuan Dam. Beginning the Work of "Heightening." View taken April, 1909.

point the Gizeh Canal takes off and runs 76 miles (122 km.) farther, discharging into the Rosetta branch of the Nile some 31½ miles (5.6 km.) beyond the delta barrage above described. Maximum discharge of the canal is 25,779 second-feet (730 sec. m.³). Number of acres irrigated by this perennial canal is 1,123,000 (455,000 hect.). Irrigation in the main is by gravity, but there are places where a lift is necessary. The water is raised by steam engines and pumps, by water wheels and by "Shadoofs." Drainage is by gravity, but there is also a pumping station which is used during a brief period.

The character of the crops is as follows: Cotton, sugar, wheat, barley, maize (corn), clover (two kinds), onions, beans, lentils, fountgreek and lupins.

At Assiut, on passing up, a dredge was at work. The answer to my question about this was: The dredge was working for navigation purposes only. It also works when required in the Ibrahimiya Canal. The work varies, sometimes none is required in the river, but is required in the canal, and sometimes some in the river and none in the canal. The average amount in

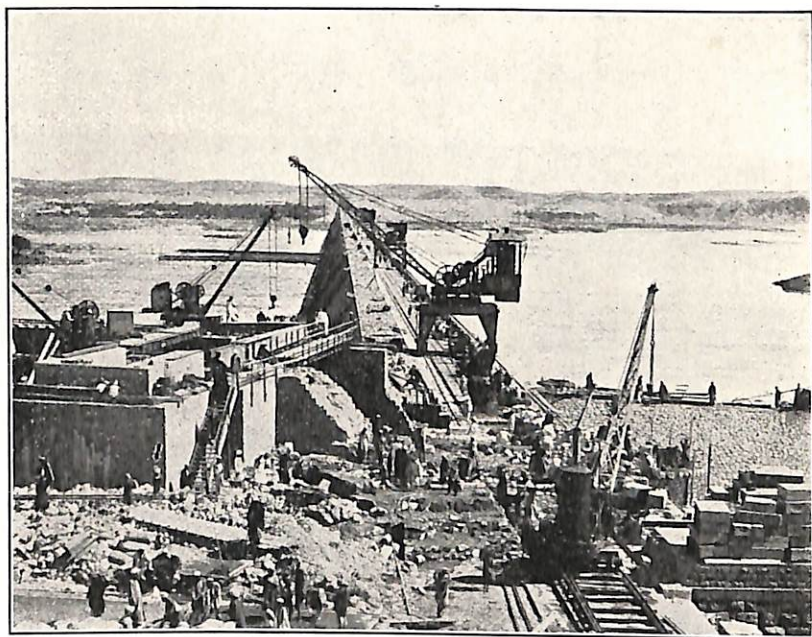


Fig. 10. Assuan Dam. Heightening Lock No. 1. South entrance, looking East. (October, 1910.)

both places in the last five years is 55,000 cubic yards (42,000 m.³).

The barrage across the Nile at Assiut for the Ibrahimiya Canal is 2,691 feet (820 m.) long, with a lock large enough for the largest tourist steamers and a swing bridge over it for the traffic across the river on the barrage, which has a wide roadway. (See Figs. 17 and 18.) There are 111 vents (openings) of 5 meters (16.4 feet) span each, arranged in 12 bays of 9 openings and 1 bay of 3 openings. Each opening has two gates, each 2.50 m. (8.2 feet) in height.

I take from "Irrigation Engineering," by Herbert M. Wilson,

M. Am. Soc. C. E., the following in regard to some features along the canal, page 122. I give the data without having the opportunity to verify them. "It irrigates about 20 large basins." "The first regulating work on the line is at Derout, where the water can be drawn from the canal by great regulating works into five branches, or passes, into the river through a large escape." "At the terminus of this canal . . . is the largest masonry escape in the world for discharging the water which comes from the canal and basins. Its maximum capacity is 80,000

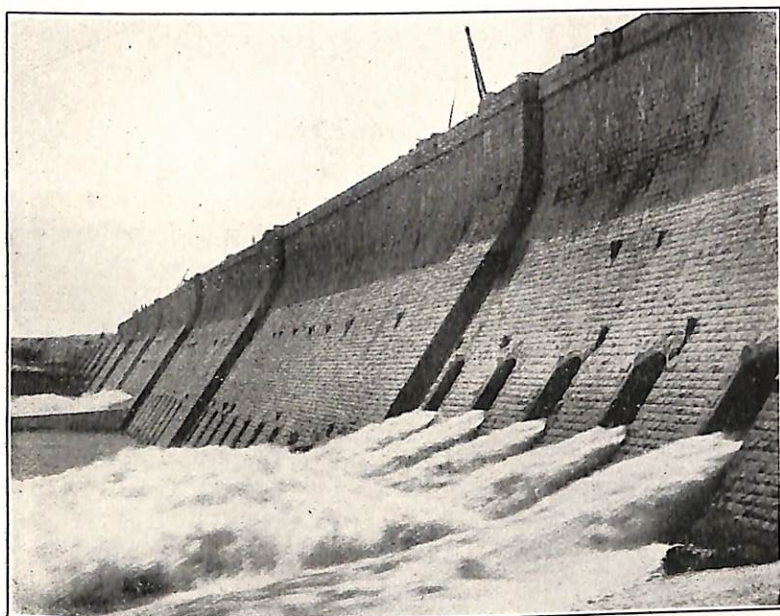


Fig. 11. Assuan Dam Heightening, looking East. (May, 1911.)

second-feet ($2,265 \text{ sec. m.}^3$) and it consists of 60 vents of 10 feet (3 m.) each, the maximum height on it being calculated at nearly 15 feet (4.57 m.). It is closed by great double gates operated by travelling cranes from the piers above."

Mr. Cope Whitehouse, son of Bishop Whitehouse of Illinois, had for many years a project for using the Fayum for a great regulating reservoir for lower Egypt, his idea being to restore the conditions that existed in ancient Pharaoh times, when Joseph opened the Ibrahimiya Canal (Bahr Yusuf, Joseph's Canal, for Yusuf means Joseph and Bahr means water) and let the flood waters into the Fayum, and at Low Nile out again from this

great natural reservoir into the Nile to furnish water to the delta.

The latest data I can find published gives in round figures as the population of Egypt (not including the Sudan) 10,000,000, and 10,000,000 acres (4,047,000 hect.) as the cultivable land of Egypt, provided it had water sufficient and at the right time. The cultivated land in 1910 amounted, all told, to 3,616,000 acres (1,463,400 hect.). But I am inclined to believe this an under-estimate for 1912, as the Ibrahimiya Canal irrigates now

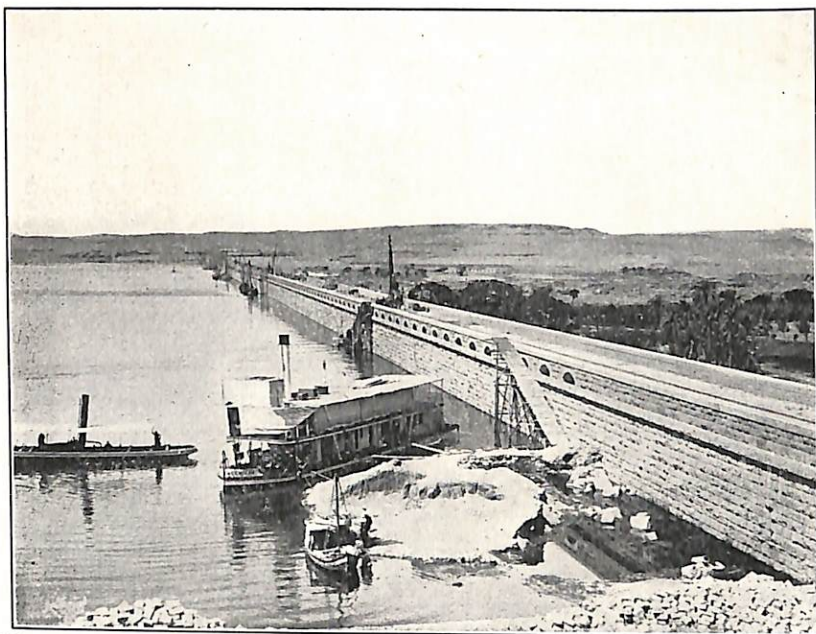


Fig. 12. Assuan Dam Heightening. South side, looking West. (April, 1912.)

1,123,000 (455,000 hect.) and according to Mr. Macdonald there are 5,000,000 acres (say 2,000,000 hect.) in the delta, of which 2,000,000 acres (say 800,000 hect.) are now in cultivation, making in these two sections alone 3,123,000 acres (or about 1,250,000 hect.) under cultivation.

This brings me to the last problem before the engineers and the government, and that is the thorough deep drainage of the delta. Lower Egypt has now more water for irrigation and for perennial irrigation than ever before in all its history. In fact, it never had perennial irrigation until the Assuan Dam began to give it, and that can do it now, for it stores up an immense amount

of water, which is let out only when low Nile comes and during the two or three summer months. When I visited the dam on the 9th of February, 1913, there were about 850 cubic meters per second (30,000 sec. ft.) coming into the reservoir and they were letting just that much through. When the discharge falls to 500 cubic meters (17,650 sec. ft.) they begin to let the water through the sluices and draw the reservoir down to keep up the flow for

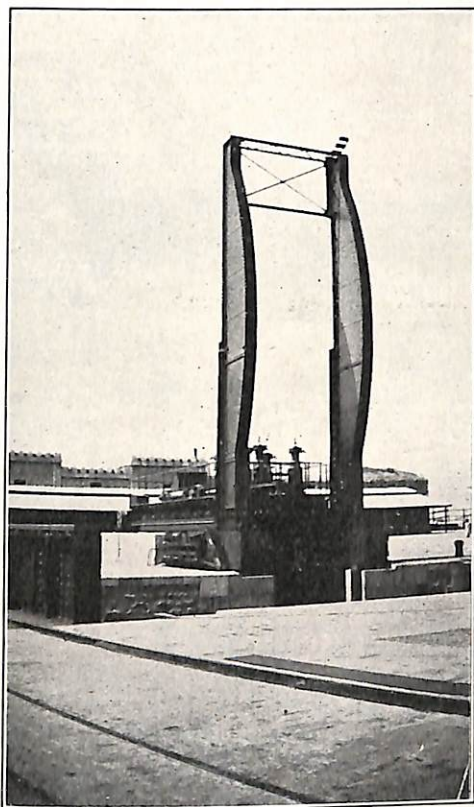


Fig. 13. Lock Mechanism of Upper Lock, Assuan Dam. View No. 1.

the Assiut Barrage to furnish the Ibrahimiya Canal with its quota and to let the remainder go on down to the Cairo Barrage. All this new water, if we can so call it "new," makes drainage imperatively necessary in the delta, especially on account of the deep roots of the cotton, which is the main and most valuable crop of the delta, there being 1,750,000 acres (700,000 hect.) in cotton of the 2,000,000 (800,000 hect.) cultivated. The roots of

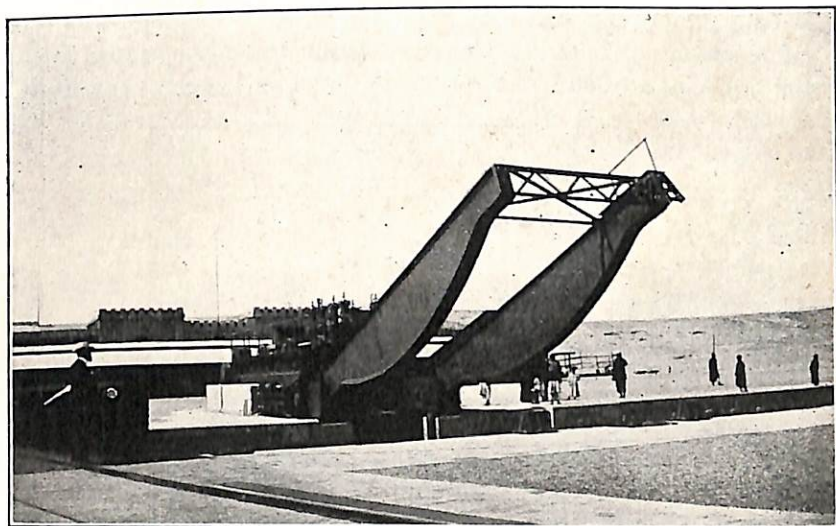


Fig. 14. Lock Mechanism of Upper Lock, Assuan Dam. View No. 2.

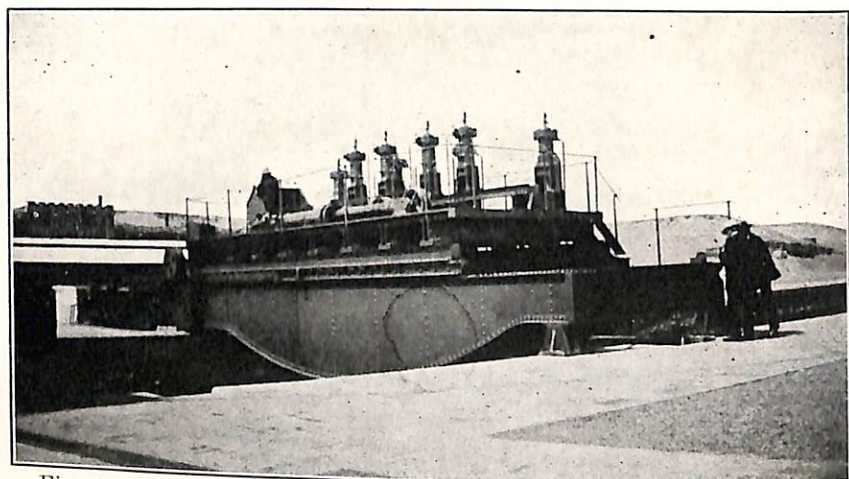


Fig. 15. Lock Mechanism of Upper Lock, Assuan Dam. View No. 3.

the cotton go down into the soil about 5 feet (1.5 m.) and it injures the cotton if the ends of these roots are kept too moist.*

There is now well worked up a project for draining the entire delta. Careful minute surveys have been made over the whole delta and it has been ascertained by the contour maps that the delta is divided into eight districts formed by the existing and disused branches of the Nile, for it is well known that the land is always highest along the line of outlets of sediment bearing rivers. Two of these districts are prepared for the drainage operations which are to be carried out by pumping. The first district will be the one back of Alexandria, and Lake Mariut will be entirely dried up. A large pumping plant will soon be instal-

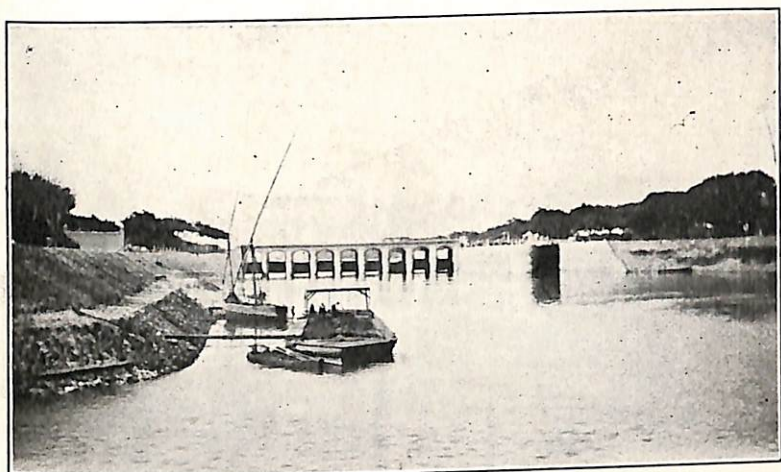


Fig. 16. Entrance of Imbrahimiya Canal from Nile, at Assiut.

led there and will lower the level of the water and sub-soil water about 6 meters (20 feet). The second section lies about in the middle of the delta. When these have been drained, the others will be taken hold of, until the whole 5,000,000 acres (2,000,000 hect.) will be cultivable land, and thus 3,000,000 acres (1,200,000 hect.) of wonderfully fertile land will be added to the agricultural land of Lower Egypt. Accompanying the drainage of the delta there will be laid out a complete system of irrigation—main canals, secondary and ditches—all draining into the drainage system. Therefore, instead of Egypt drifting into hopeless

*In April last the Nile was reported lower than at any time in the last one hundred years, viz, 230 cubic meters per second (8,120 second-feet).

insolvency, whither it was rapidly tending a few years ago, and her people into the despair of abject poverty, Nile water, utilized and distributed with impartiality, is making, and will still further make, strong, hopeful men of her fellaheen, and is filling her exhausted treasury. The original Assuan dam has repaid its cost over and over again and the new work we have briefly described and which was put into use only a few months since, will add enormously to the productiveness and wealth of Egypt and to the happiness and general welfare of her people.

Monday, February 17, saw us off for Gibraltar, saying goodbye to our Cairo friends and the interesting and hospitable Shepherd's Hotel, and, assisted with our baggage on board the *China*

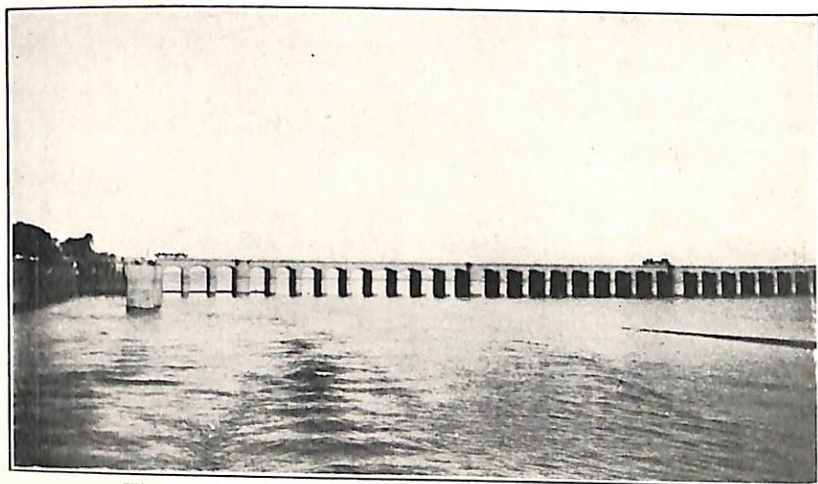


Fig. 17. Barrage across Nile at Assiut, showing Lock.

at Port Said by Mr. Koenig, the Resident Engineer of the Suez Canal, we steamed out of the harbor, taking a last look of the heroic statue of Ferdinand de Lesseps and the breakwater, and started on our six days' voyage, with one day at Marseilles, where we arrived punctually at 9 a. m. on Saturday, February 22, the weather pleasant and cool and excellent for what was before us until 5 p. m., when we were to sail for Gibraltar.

Mr. Batard, Chief Engineer of the Port, and Mr. Bourgougnon, Chief Engineer of the Marseilles-Rhône Canal (Fig. 19) now under construction, were on the dock to meet us and take us first in Mr. Batard's sea-going launch about 5 miles (8 km.) along the route of the new canal, the terminus of which is in the port of Marseilles, straight to the entrance of the tunnel now under con-

struction through the rocky ridge that separates the Bay of Marseilles from the "Etang de Bolmon," and thence along the shores of the large Etang de Berre, about 8 miles (12.8 km.) in all, and thence along the outlet of these lakes to the "Golfe de Foz," along the northern shore of that water direct to ancient Arles, following the latter part of the way the course of the Rhône. The total length, Port of Marseilles to the Rhône at Arles is somewhat less than 50 miles (80.5 km.). It is built to bring the Rhône river traffic from Lyons and above direct to Marseilles. It is being built by the French government, with some assistance from the Chamber of Commerce of Marseilles. The large Rhône barges can then avoid the dangerous route of 25 miles (40.2 km.) around

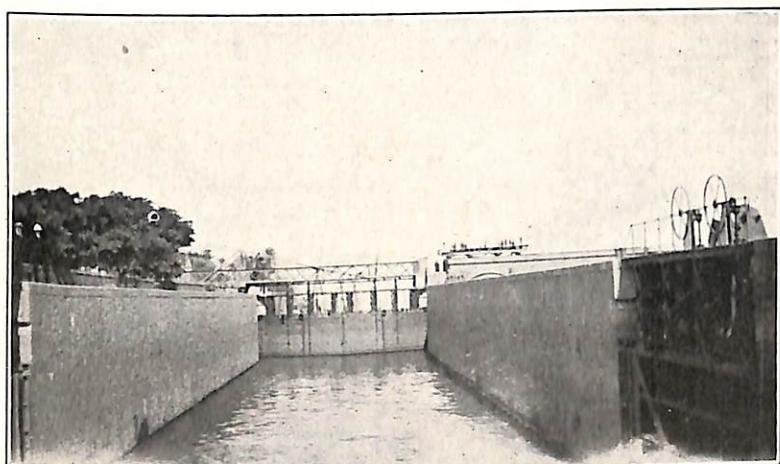


Fig. 18. Lock through Barrage at Assiut.

Cape Couronne from the mouth of the Rhône, or rather from the mouth of the St. Louis Canal to Marseilles.

Before describing the tunnel, which is the principal feature of interest, let me say that the mouth of the Rhône has an interesting history. For centuries the question of improving it for the Rhône navigation had been a matter of study, projects and efforts, until the government started to build dikes to close the smaller outlets of the delta and two jetties at the principal mouth. But two serious errors were made, the jetties were too far apart and the methods of construction were too slow. The silt and sands protruded beyond the advancing jetties, always in advance, the bar moving outwards until, weary of "chasing a rainbow," it was decided to build a lateral canal (Canal St.

Louis), about $3\frac{1}{2}$ miles (5.6 km.) long to debouch into the Gulf of Foz.

The disappointment and its causes are shown, with sketches, in my "History of the Mississippi Jetties," published by John Wiley & Sons in 1880. The conditions and history were carefully examined by Captain Eads, at the time of his visit to Europe in 1874 to learn the facts about many improved river mouths, to support his arguments for the bill then before Congress for improving the mouth of the Mississippi River by means of jetties. His opponents were using the history of the mouth of the Rhône

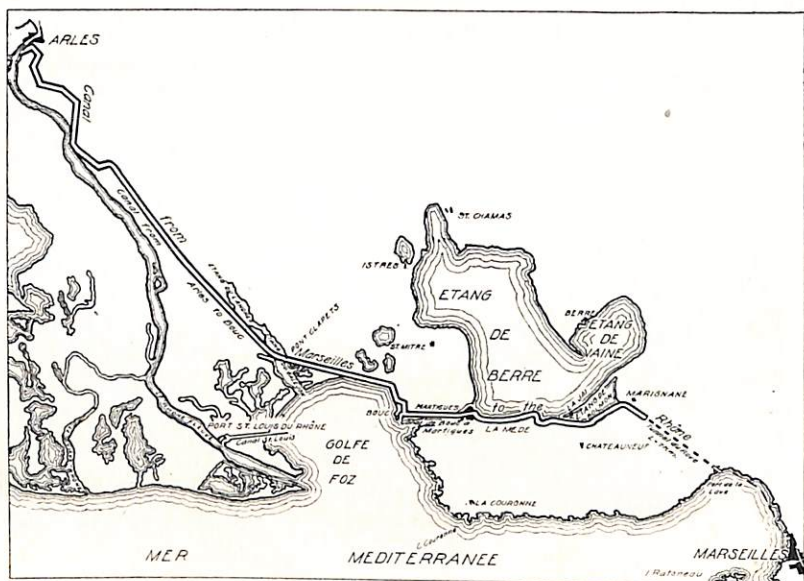


Fig. 19. Marseilles-Rhône Canal.

as an argument in favor of the Fort St. Philip Canal from the Mississippi to Lake Borgne and against the jetty proposition. Now, the Canal St. Louis is to be practically abandoned and one 50 miles (80.4 km.) long is to be built.

The tunnel is probably one of the most interesting rock tunnels ever undertaken in that it is, no doubt, the largest and one of the longest barge canal tunnels in rock. The tunnel, lined throughout its nearly $4\frac{1}{2}$ miles (7.2 km.), is 22 m. (72.2 feet) wide inside the lining, and the crown of the arch (nearly semicircular) is 9.90 m. (32½ feet) high. The depth of water is to be 3 m. (10 feet). The plans illustrate the whole process of excavation, cen-

tering and lining, and are well worth the study of tunnel and canal engineers.

Briefly, as the detail plans are too extensive and numerous to be published entire, the process is as follows (see Fig. 20): A heading on the left at the base 3 m. by 3.25 m. (9.8 by 10.7 feet), then one on the right at the same level and same size, then the enlargement of the two inwards to give room for a track and

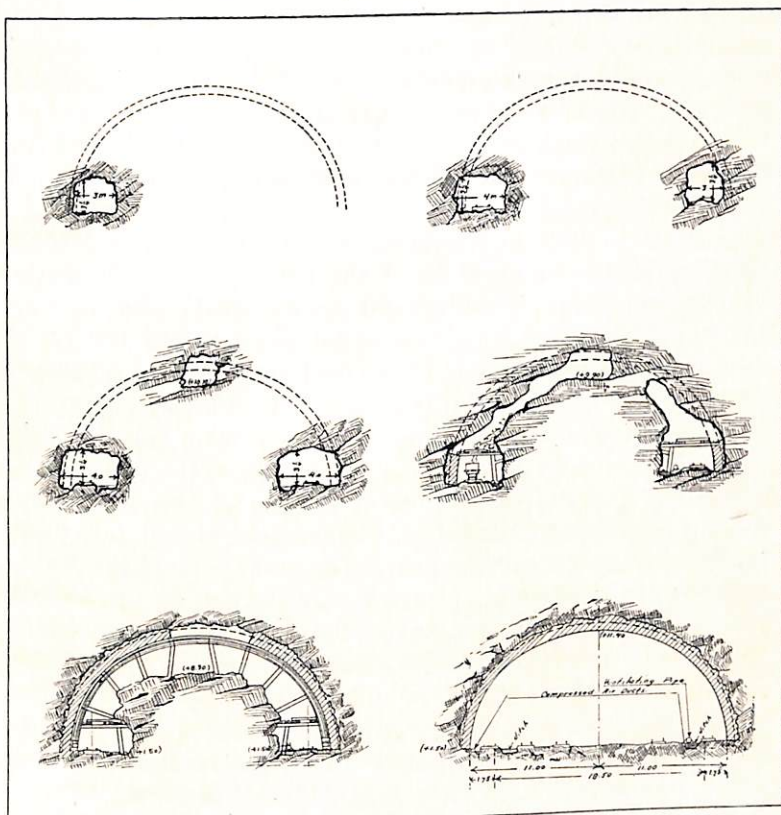


Fig. 20. Tunnel of Rhône-Marseilles Canal, showing process of excavation.

ditch for drainage, then a small heading at the summit of the arch, then the enlargement upwards of the two side headings to connect with the top heading, with a staging to receive the falling rock to be dropped into small dump cars on the track, the permanent lining at the same time started on each side, then the enlargement of the excavation under the roof on both sides, which gives a chance to put in heavy centering on short posts.

resting on the same mass core of unexcavated rock, then the masonry lining over the advancing centering completed, the centering then removed and carried forward and the bench removed. The work is done by compressed air and it has the usual ventilating machinery and pipes, compressed air pipes, drainage ditches, etc. The rock is quite varied in character. Dolomite of the Upper Jurassic, limestone, sequannian (above the Jurassic), and a mixture of the two. Suitable stone for the lining is found in the materials removed by the tunnel excavation. The "legende" in French, in much greater detail than above, is well worth study by those especially interested in such works. The contractors for the entire work are Messrs. Chagny & Co., who have built the Loetschberg tunnel and approaches between Bern and the Simplon, recently completed.

Later in the day, in company with Mr. Batard and Mr. Bouteville, we visited many parts of the port to see the operation of loading, unloading, handling and storing goods, also the enlargement of a large dry dock now under construction and a visit to the new quays in extension of the port, forming a new basin. The water is very deep and all this work is necessarily done by the use of compressed air caissons. This new basin is called "Bassin de la Madrague." In all the existing basins the quays or docks are at right angles to the line of the port. The new basin and the future basin, "Mirabeau," have piers placed diagonally to the inner quay wall of the port. The outer ends of the Madrague Basin, which is 400 m. (1,312 feet, nearly $\frac{1}{4}$ mile) long, is in 18 m. (59 feet) of water, while the outer protecting dike is in 35 m. (115 feet), one of the deepest dikes of the world. The future extension of this great dike follows the contour of about 37 m. ($121\frac{1}{2}$ feet) and the end of the Mirabeau dock will have to be built in 28 m. (92 feet) of water. The inner line of wall of the port now under construction is built in about 8 m. (26.2 feet) of water and extends to the mouth of the tunnel of the Marseilles-Rhône Canal, about 5 miles, with a protected opening into the sea about 2,700 m. (1.7 miles) beyond the outer pier of the Madrague Basin. The canal terminal channel in this 1.7 miles is to be about 1,000 feet (300 m.) wide and the space between it and the shore is to be filled in for commercial purposes, with streets and bridges to reach the future basins and piers of the port. The French government and the city of Marseilles are determined to hold and increase the commerce of the port, if pos-

sible, in its competition with Barcelona on the west (the port of which is being radically enlarged and improved) and Savona, Genoa, and Naples on the east. The work above outlined will necessarily cost an immense amount of money, one item alone—the tunnel with its $2\frac{1}{2}$ million cubic yards (1,900,000 m.³) of excavation and a costly lining, is not the least item in the estimate.

Our friends delivered us to the *China* five minutes before she sailed, and on Monday afternoon, February 24, we were at the Hotel Bristol in Gibraltar. We were again among friends, for Sir H. Arthur Yorke, Royal Engineer, Engineer of the Board of Trade, London (so well known to all American railway men, as he has often been the delegate of the British government to railway congresses and is equally known to navigation men, as he is the government's member of the Permanent International Commission of the Navigation Congresses and attended, with Lady Yorke, the Philadelphia Congress, and they were with us on the excursions in the United States and Canada), knowing that we were to visit Gibraltar and that we might be debarred from seeing much that a British subject might see, wrote to Col. A. Grant, Royal Engineer in charge of all military works at Gibraltar, informing him of our expected arrival and asking his kind attention. Colonel Grant is also chairman of the Joint Sanitary Board of Military and Naval Officers, that has charge of the streets and drainage and other public improvements of the city. We also knew personally Commander Liversidge of the Royal Navy, who has charge of naval works, repairs, etc. Colonel Grant promptly detailed an engineer officer, who has charge of all works at Europa Point—barracks, houses, and batteries—to accompany us to the heights. We ascended to the height of 1,000 feet (300 m.) and would have gone to the highest point of 1,396 feet (425 m.) except for the strong wind that blew furiously that day on the heights. We did go to the end of the "Mediterranean Steps," where we could see the roof of galvanized corrugated iron which has been attached to the slopes of the mountain to catch the rainfall and conduct the water into huge tanks cut in the living rock and from thence by a tunnel under the hill to the city and the port; and yet there is a deficiency of water, which no doubt more roofing and more tanks will supply. The batteries, housing of the soldiers, the range finders and other special features I am not permitted to talk about, but it was a satisfaction to be told by Colonel Grant on the evening before

our departure that I had seen more than most people see. Anyway, the constructions, from an engineering and I may say, military, point of view were extremely interesting and the naval works as well, which are well equipped with all modern facilities—dry docks and machinery for the repair of the largest war vessels and the most delicate, like torpedo boats, submarines, etc. All this was shown us by Commander Liversidge. The extensive modern docks cost \$25,000,000 (125,000,000 frs.).

After a two days' visit at Gibraltar we went over to Algeciras on our way to Southern Spain. It was a pleasant surprise to find in the Hotel Reina Christina one of the most comfortable and modern hotels in Europe and the wonder I always had had, how the members of the late Algeciras Conference could have lived in this little Spanish town, no longer existed, for the hotel outside the town, with its beautiful gardens and walks, was built for the members of this conference, although the conference room was in the municipal building in the town. The hotel Reina Christina and another good one, beautifully situated at Ronda, are owned and operated by the Bobadilla and Algeciras Railroad Co., an English company, the manager of which is Mr. Morrison, an experienced and very able railroad manager, who is also on the Board of Argentine, English and Mexican Railway Companies. I had a card to him from Col. W. Dally Jones, a retired British officer with whom I am interested in an important Swiss-Italian Railway project, and Mr. Morrison gave us a reserved compartment on the train and telegraphed his inspector at Bobadilla to attend to our transfer to the Granada train, whither we were bound.

For sixty years, since reading that beautiful classic of Washington Irving's "Tales of the Alhambra," I had longed to see it and I am glad to say there was no disappointment. The beauty and the art, the Moorish architecture and decorations are still there to delight the eye. The view of Granada below you and of the beautiful valley and plains in the distance, as far as the eye can reach from this lofty point, are most beautiful, and within sight is the point where Isabella had her quarters at Santa Fé during her siege of Granada and where Columbus came on his "recall," and almost within sight in the opposite direction, 9 miles (14.5 km.) from Granada, is the Pinos-Puente (bridge) at the foot of the Sierra, where Columbus in 1492, after having been dismissed by Isabella and had actually started to offer his pro-

ject to the king of France, was overtaken by the queen's messenger and recalled. This scene, by the way, is illustrated by a beautiful painting by the well-known American painter, Mr. Heaton, who visited the spot before executing the work. It now hangs at the head of the stairway leading to the Senate chamber at Washington, D. C.

To know that you are in the hotel, the predecessor of which and on the same spot was the home for a while of Washington Irving, and that we visit the very room near the Archives of the Alhambra given to him in which to write his "Tales," and to call up the great past and all who have lived within these walls, lends an additional interest to the beauties of buildings and country.

On March 4, we went to Seville and there we were pleasantly surprised by much that had not been anticipated and is not in the guide book. The day following our arrival we called on the United States Consul, Mr. Chas. S. Winans, who offered to arrange for a visit to the port works with Mr. Molini, "El Presidente de la Junta de Obras de la Ria del Guadalquivir y Puerto de Sevilla," to give him his position in full; but on our return to the Hotel de Madrid we found Mr. Molini's card with this note, "au nom de Mr. Brockman of Madrid," who was one of the Spanish delegates at the Philadelphia Navigation Congress and who had kindly asked Mr. Molini to call on us.

The following day in company with Mr. Winans and Mr. Molini and one of his principal assistants we made an inspection of the river in the motor launch of Mr. Molini, about 15 miles (24 km.) and then on our return a drive to see the principal work now under construction, the Alphonso XIII Canal, which is a "cut-off" that eliminates a very pronounced bend in the river just below the port.

The subject of a port at Seville and the improvements of its facilities and particularly the improvement of the river and the bar at its mouth in the sea is of sufficient importance for a complete exposition of the project, but it would lengthen too much this summary account of our travels. It is not an exaggeration to say that the commercial improvements under construction will in a few years raise Seville to an entrepôt of the first class. It is situated by the course of the river 100 km. (62 miles) from the sea. This makes it essentially a port of "penetration" into the country and for that reason one of great importance, lying, as

it does, in the midst of a rich agricultural country. Within three years vessels of 8,000 to 10,000 tons can reach Seville, and as they come from the sea will find a depth of at least 30 feet (9 m.), a channel well lighted and buoyed all the way from the sea offing to the city and, on arrival there, will find a quay of adequate length for many steamers, the full depth alongside and all of the latest facilities for cargo—cranes, sheds, and warehouses.

A brief sketch, at least, should be given of the history, physical features, the improvements and the commerce illustrated by the accompanying plans (Figs. 21 and 22). The improvements of the Guadalquivir were begun in 1794 by the straightening of one

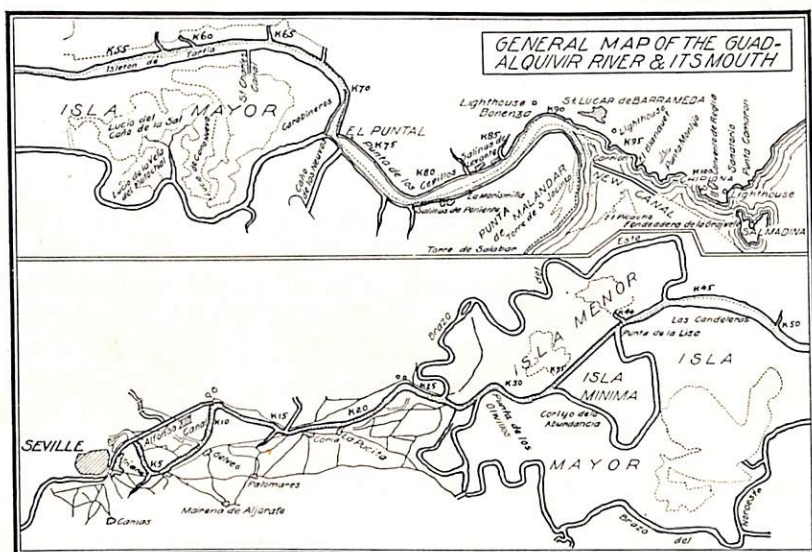


Fig. 21.

of the most pronounced bends at the Merlina cut-off. In 1816, the Ferdinanda cut-off was made. Then, up to 1863, no further work of improvement was undertaken. The draught of vessels was limited to 1.5 m. (5 feet) and the total annual traffic was 80,000 tons. Between 1863 and 1868 the state, by the insistence of the commercial interests, executed works which cost about 11,000,000 pesetas (about \$2,200,000 par value), which was expended in improving the navigation of the river and building the first docks (quays). The commercial interests contributed 1,200,000 pesetas (\$240,000) of the above amount. This improvement increased the navigable draught from 5 feet (1.5 m.) to 15 feet (4.5 m.) and the maritime traffic rose immediately to 108,000

tons. Between 1868 and 1871 the whole work stopped and not even were the navigation conditions maintained. At the end of 1870 there was formed the "Junta de Obras" (Board of Works), of which Mr. Molini is president and chief engineer and has been for many years. Since that date the development has been continuous up to the present time. In the year 1910 the traffic in tons of freight amounted to 1,250,152. In the maritime part of the commerce there were 1,407 vessels: 943 Spanish, 250 English, 69 Norwegian, 46 German, and 99 of various flags. There are three navigation companies domiciled at Seville, owning 43 steamers. The amount spent by the Junta, 1871-1910, is 52,710,-

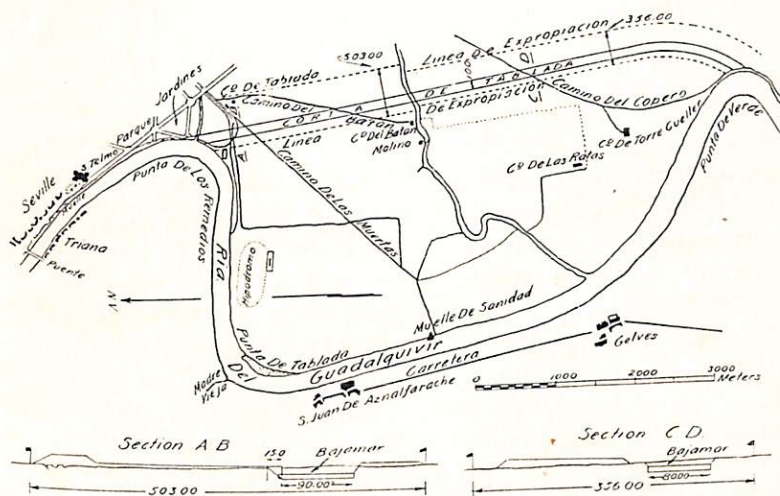


Fig. 22.

497.20 pesetas, over \$10,000,000. On June 23, 1903, a general plan of improvement was approved by the government, which will be completed in the year 1916, when the larger class of vessels can reach Seville. An estimate was made by Mr. Molini of the work, which would remain to be done on December 31, 1910, on the plan above mentioned:

	Pesetas.
On improvements of the port-----	12,755,324.78
First section of the river-----	3,350,000.00
Second section of the river-----	350,000.00
Total-----	16,455,324.78
Or, about-----	\$3,200,000.00

The "Canal de Alphonso XIII" shown on the plan (Fig. 22) and referred to before, is a separate work and will cost, all told, about 10,200,000 pesetas, say \$2,000,000, and this with other rectifications of the river will materially reduce the height of the floods, which have in the past been sometimes quite disastrous by the overflow of the banks, submerging the lower part of the city. The estimate of the amount to spend annually for the present three years is as follows:

	<i>Pesetas.</i>
1911 -----	1,234,000
1912 -----	2,034,000
1913 -----	1,604,000
Total-----	4,872,000
Or, about-----	\$974,000

In doing the work, including principally now the completion of the Alphonso XIII Canal, 330 feet (100 m.) wide at the bottom, there is an excellent outfit of dredges and excavators. There are four like the one used on the Barge Canal of New York, called the *Lubecker*, which operates by an endless chain of buckets, the machine moving on rails above the water on a path of its own. Two of these can excavate to a depth of 51 feet (15.5 m.). There is a plentiful supply of locomotives and dump cars. Nearly two-thirds of the 10,000,000 cubic yards (7½ million m.³) has been removed at an average cost of 9¼ cents per cubic yard (60 centimes m.³). The work is being pressed day and night by the use of an electric light installation.

The entire channel from Seville to the sea will be 100 meters (330 feet) wide, and in the sea at the river mouth it is proposed to make and to buoy and light a channel 656 feet (200 m.) wide and 32 feet (9.7 m.) deep at high tide. The tide rises about 4½ feet (1.4 m.).

Every effort will be made to complete the entire work, river entrance and channel and all port facilities, before 1916, as that year has been selected for an International Exposition to be held at Seville. It will be purely an *Hispano-Americana* Exposition. It is hoped that many of the exhibits of North and South America at the San Francisco Exposition will be sent over to Seville, which can easily be done, as the exposition opens the year following that at San Francisco. It have promised Mr. Molini—and it was made at my own suggestion—that I would recommend

this to my friends in the United States. The commercial features are important to Americans as well as to Europeans.

When the navigation conditions have become what we have described, when steamers drawing from 26 to 28 feet (8.0 to 8.5 m.) and of from 8,000 to 10,000 gross tons can comfortably reach Seville, there will be an importation and exportation much beyond what has been possible hitherto. The lowering of freights to and from Seville by the increase of the tonnage of steamers, the development of coastwise traffic as well, produced by the increase in the amount of merchandise received and exported—all will tend to increase the trade of Southern Spain.

There is another important work now developing, and that is extensive irrigation between Cordova and Seville. This will result in the intensive cultivation of cereals by modern and more satisfactory methods of agriculture. During the entire year there will be sure and abundant crops, that now often fail through want of rain when it is most needed. During the summer season there is scarcely any rain, the average for the whole year is only about 23 inches (58 cm.). The work of irrigation has begun on the main canal, taking the water from the Guadalquivir. The total length, including main canal and principal branches, is over 150 miles (241 km.). The irrigated area will contain about 300 square miles (192,000 acres or 77,000 hect.) on the left bank of the river. To supply sufficient water at times of low river six reservoirs will be built, containing about 260,000,000 cubic meters of water (9,180,000,000 cubic feet). On the right bank there will be five short canals with a total length of 58 miles (93 kilom.), each with its own reservoir; the area to be irrigated being 40 square miles (25,600 acres or 10,360 hect.). The dams of the reservoirs will range from 70½ feet (21.5 m.) to 180 feet (55 m.) high. The estimated cost of the entire system is over 40,000,000 pesetas (\$8,000,000). The proprietors of the lands benefited are to pay one-half and the general government one-half. A satisfactory arrangement has been made by which the property owners are to pay 10 per cent during construction and 2 per cent annually afterwards for twenty years. The government is to arrange in the annual estimates for enough funds to keep the work along. Mr. Winan's report in *Daily Consular and Trade Reports* No. 160, July 11, 1911, page 154, will give all necessary details. It will be seen, from the statements about

Seville, that this part of Spain is awake to the necessity of developing its commerce and agriculture.

Before leaving the subject of Seville, I wish to refer to an exceedingly interesting historical feature near by and reached by a convenient carriage ride from the city: *Italica*. It was founded by Scipio Africanus about 205 B. C. as a refuge for his veteran soldiers. In the reign of Augustus it became an independent municipality and it boasts of being the birthplace and early home of three of the Roman emperors—Trajan, Hadrian, and Theodosius. It was evidently a city of considerable importance, though now practically nothing remains of it except the ruins of the amphitheater, about 285 feet long by 200 feet wide. Considerable of it is still intact, but some terrible catastrophe or upheaval by man or nature has thrown about some enormous fragments of the stone and concrete work. One of the most interesting historical facts connected with it is that it was the home of Cornelius, the Centurion, who came to Peter after his dream—in which there was let down from heaven a sheet full of all manner of “unclean” animals, and the Lord told him to arise, slay and eat, and soon there appeared the servant of Cornelius, who, as a Centurion, was in Syria in command of 100 soldiers.

One of the interests in travelling in these old countries is unexpectedly finding facts that connect one with the past in a way to make it seem almost like the present, and this is true particularly in Egypt, until, after a while, looking upon scenes of the great and distant past that stretch back 6,000 or 8,000 years, even old Roman and Jewish times—the prophets and the birth of Christianity—seem really modern, and to an American, who calls anything old that goes back a couple of hundred years, these old civilizations make an irresistible appeal that can not be put aside.

It would, no doubt, interest you to hear the relation of many incidents of our travels elsewhere in Southern Spain, Cordova, Toledo, the Escorial and Madrid, but I will only refer to some interesting matters in Madrid, where four of our friends, who were delegates to the Philadelphia Navigation Congress, showed us many features of interest. These friends are Mr. Guillermo Brockman, Capt. Xavier de Salas, Capt. José Ma Barrera, both of the Spanish navy, and Prof. Juan Manuel de Zafra of the Royal Technical School. Through their kindness we visited the Club de Madrid, one of the finest of club buildings, and lunched

with them there and examined the building and later examined two notable structures which are being built under the charge of Mr. Antonio Palacios, one of the leading architects of Madrid. One of the buildings is a hospital for poor workmen, the funds being furnished by a wealthy lady—7,000,000 pesetas (\$1,400,000). The other is a beautiful chamber of commerce, to cost

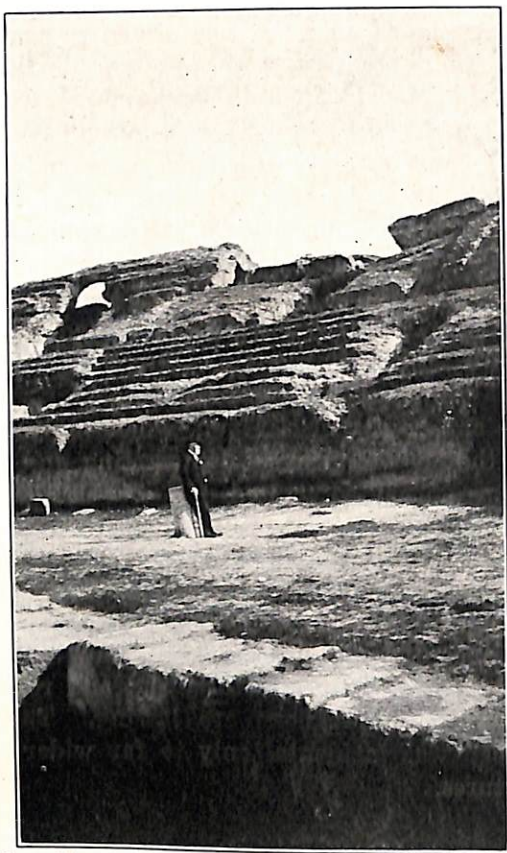


Fig. 23. Arena at Italica near Seville, Spain.

15,000,000 pesetas (\$3,000,000). By the kindness of Captain de Salas we saw the game of pelota played, visited the royal palace on Palm Sunday to see the King; also the royal stables, where the array of horses, ponies, harnesses, saddles, carriages, and automobiles is very extensive and interesting; visited the house of the brother of Captain de Salas to see the crowd go by to the bull fight on Palm Sunday, a function on behalf of the widow and children of a "toreador" who had been killed in the ring two

weeks before; and, conducted by Mr. Brockman, we visited Professor de Zafra, who showed us all the features of the Royal Technical School. From a quite careful examination of it I am sure it is equal in its appointments to any technical school in the United States, although much smaller than some of ours.

Madrid is improving: better street paving, a wide boulevard being under construction to cut through the city and one built around it, very much like the new Avenida Central and the Beira Mar at Rio de Janeiro, or the Avenida de Mayo at Buenos Aires. The new Madrid Palace Hotel, where we were guests, has 800 rooms and 800 bathrooms, with telephone in each room, and in the basement is a café with 1,850 seats and a billiard room with 57 tables.

I could not close this long account of our journey without saying that on our arrival in Paris we were entertained in a most pleasant way by several of our friends of the Philadelphia Navigation Congress of 1912; after which we turned our faces toward Bern and home. It is with great pleasure that I take this opportunity to tell the story of this most interesting trip of three months. We can only wish for you, whenever you may take a similar trip, that it will prove as interesting and in every way as successful a journey as we had.

This descriptive paper may possibly convey the impression that we were looking only for engineering works of the present day; far from this. We also desired to see the interesting and instructive scenes of lands differing from our own in race, language, customs, history, architecture, art, and religion, and we found it all. The impressions are lasting. The engineering above described was incidental only to far wider and more interesting features.



116361

